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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 112, Nov. 16. 5734

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WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROGERS & RUSSELL, LTD., Queen's Wharf, Hammersmith.
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See half-page Advertisement page 76, Nov. 2.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

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The Institution of Mechanical ENGINEERS.

Thomas Hawksley Lecture, 1917.

CAPTAIN H. RIALL SANKEY, C.B., R.E., Member of Council, will Deliver the above Lecture on

"HEAT ENGINES,"

in the Hall of the Institution of Civil Engineers, Great George Street, Westminster, Friday, 30th November, 1917, at Six p.m.

VISITORS INVITED. J 482

IMPORTANT NOTICE TO ALL ENGINEERING FIRMS ENGAGED ON MUNITION WORK.

Institute of Ophthalmic OPTICIANS.

President: The Rt. Hon. Lord Aldenham, M.A.

The attention of all engineering and manufacturing firms engaged on important Munition work, and especially those firms employing a large number of female workers, is directed to the following statement appearing in Memorandum No. 15, entitled, "The Effect of Industrial Conditions upon Eyesight," and issued by the Health of Munition Workers' Committee appointed by the Ministry of Munitions:—

"NOTWITHSTANDING THE IMPORTANT BEARING WHICH GOOD EYESIGHT MUST HAVE UPON OUTPUT, THE QUESTION IS NOT TO-DAY RECEIVING ATTENTION AT THE HANDS OF THOSE WHOSE DUTY IT IS TO OBTAIN THIS OUTPUT."—(Par. 5).

The Institute of Ophthalmic Opticians has, thanks to the patriotic voluntary enrolment of a large number of its members, been able to formulate an Industrial Sight-Testing Scheme, under which it undertakes to provide (voluntarily) qualified Opticians to test the eyesight of factory workers.

N.B.—A qualified Optician is understood to be an ophthalmic optician who has passed either the Sight-Testing Examination of the Spectaclemakers' Company, whose examinations are under the direction of the Rt. Hon. Sir Wm. Hart-Dyke, M.A., and among whose examiners are Mr. H. G. Critchley, M.A., M.D., and other medical men and scientists, or that of the British Optical Association, whose examiners are R. B. Clay, D.Sc., Edwin Edser, A.R.C.S., W. J. M. Ritties, M.D., F.R.C.S., W. Haldane Gee, B.Sc., Albert Griffiths, D.Sc., W. J. May, F.R.G.S.

Firms desiring full details of this important scheme are requested to write to

Mr. J. HARCOMBE CUFF,
Secretary,
Institute of Ophthalmic Opticians,
25, Friern Barnet Road, London, N. 11.

J 420

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Tuition in separate subjects, if desired.

Thorough, rapid, efficient coaching under my personal supervision.

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60, Shakespeare Crescent, Manor Park, E. 12.

J 356

Inst. C.E., I. Mech.E., B.Sc.,

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APPOINTMENTS OPEN.

BOROUGH OF SWINDON
EDUCATION COMMITTEE.

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Principal—Mr. G. H. Burkhardt, M.Sc.

The Committee invite

Applications for the Per-

manent appointment of HEAD of the ENGINEERING DEPARTMENT of the Technical Institution, at a commencing salary of £270 a year. Candidates must be ineligible for military service. Teaching experience, including laboratory work, and practical experience in an engineering works essential, and ability to take some electrical work (during the period of the war) desirable. Further particulars, if definitely specified, will be supplied by the Principal.—Application to be made to the PRINCIPAL, Technical Institution, Swindon, by the 8th December, 1917.

W. SEATON,
Secretary to the Education Committee.

20th November, 1917. J 521

KENT EDUCATION COMMITTEE.

GRAVESEND AND MAIDSTONE JUNIOR TECHNICAL SCHOOLS.

Required, in January, Assist-

ANT MASTERS. Graduates in Engineering with workshop experience preferred. Initial salary £160 a year. Application forms may be obtained from the undersigned.

FRAS. W. CROOK, J 526
Sessions House, Maidstone,
November, 1917. Secretary.

MONTGOMERY COUNTY COUNCIL.

Applications are Invited for

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Commencing salary £400 per annum, rising by annual increments of £25 to £500, if work considered satisfactory by the Council, together with a travelling allowance of £100 per annum and a free first-class railway pass in the county. An office and clerk will be also provided at the expense of the Council.

Applicants must be members of the Institute of Civil Engineers and qualified architects, and devote their whole time to the work of the Council.

A printed list of the duties of the Office can be had on application accompanied by a prepaid foolscap envelope.

Duties to commence as soon as possible after appointment, and applications to be sent in to the undersigned together with not more than three copies of recent testimonials, by not later than the 10th December next.

Candidates canvassing directly or indirectly will be disqualified.

GEORGE R. D. HARRISON,
Welshpool, Clerk of the Council.
13th November, 1917. J 493

CHIEF DRAUGHTSMAN REQUIRED.

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DRAUGHTSMAN are REQUIRED by an Aeroplane Firm. He must have organising ability and be really capable of taking charge of a large drawing office. Only first-class men need apply. Excellent prospects and remuneration.

Applications should be submitted by letter, state age of applicant, and give full details of training and experience. No one engaged on Government work or living more than 10 miles away, need write.—Address, J 502, Offices of Engineering.

Wanted, Energetic Accoun-

TANT and CASHIER, for controlled Engineering Works near Leeds. Good prospects for suitable applicant; permanent situation. No one already employed on Government work will be engaged.—Apply, stating age, salary, &c., in confidence, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 490.

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Experienced Cost Clerk

REQUIRED by engineers, S.E. London. Knowledge foundry costs and practical works experience preferred. No applicants residing outside radius of ten miles, or already employed on Government work can be engaged.—Write, stating age, experience and salary required, to J 542, Offices of Engineering.

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CHARGE of Electric Supply Co.'s Stores Works hours. Good wages and war bonus to suitable man.—Write, stating age and experience to E.F., care of J. W. Vickers & Co., Ltd., 5, Nicholas Lane, E.C. 4. J 501

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Chemist, First-class, Required

for large manufacturing concern. Must be well up in metallurgy (especially steels) and photomicrography. No one already engaged on Government work or residing more than ten miles away need apply.—Address, giving details of experience, salary required, &c., J 347, Offices of Engineering.

Wanted, by an Old-estab-

lished progressive Firm of ball-bearing manufacturers in the Midlands, at present engaged on important Government contracts, MACHINE SHOP SUPERINTENDENT, Chief INSPECTOR and Tool Room FOREMAN. Also Up-to-date MAN on modern steel treatment, hardening, &c.; good prospects offered for suitable man requiring permanent position in a growing industry. No man already engaged on Government work will be engaged.—Apply, stating full particulars, experience, references, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 4045. J 447

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the East Midlands, now engaged on urgent war work, REQUIRE the SERVICES of a GENTLEMAN of wide commercial experience to assist the Principals in dealing with Munitions Contracts.

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for large Engineering Works in neighbourhood of London, employing several thousand hands. Candidate must have a thoroughly sound training and be thoroughly conversant with modern machine shop methods. No one at present employed on Government work or resident more than ten miles away will be engaged.—Address, state age and experience, in confidence, J 472, Offices of Engineering.

Works Chemist Wanted,

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producing vessels up to 5000 tons deadweight, REQUIRES a MANAGER. A gentleman with combined practical and commercial experience would receive liberal terms.—Applications, which will be treated in confidence, should be addressed to G.D., care Charles Walton, Esq., Solicitor, 101, Leadenhall Street, London, E.C. 3. J 503

Wanted, in a Government

Factory, an ASSISTANT MANAGER. Must have thorough knowledge of gun construction, manufacture of breech mechanisms, and be well versed in latest methods of shop organisation and control of men. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 4056. J 495

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ASSISTANT WANTED for Controlled Engineering Works (Glasgow district). Permanent position to suitable man; salary according to experience. No person at present employed on Government work will be engaged.—Apply, stating age, qualifications, past experience, and salary expected, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 406.

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FIXER. Must have thorough knowledge of Premium Bonus System in connection with aeroplane and motor engine parts. No one already on Government work will be engaged.—State experience and wages required to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 404.

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Aeroplane Factory, N.W., has

VACANCY for a capable RATE FIXER, used to work in connection with light metal fittings, preferably, but not necessarily with previous experience of aircraft work. No one residing more than ten miles away or already engaged on Government work need wri te toBOX 679, Sells Ltd., 168, Fleet Street, E.C. 4. J 492

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e ce in coke oven plant, coal-handling machinery, and chemical or tar plants, WANTED Immediately.—Apply, stating experience, age, and salary required, to KOPPERS' COKE OVENS AND BY-PRODUCT CO., 301, Glossop Road, Sheffield. No one already employed on Government work will be engaged. J 548

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Draughtsman Required for

Controlled Blast Furnaces and Rolling Mills on the North-East Coast. Men already on Government work need not apply.—Apply your nearest EMPLOYMENT EXCHANGE, stating age, experience, and salary required, quoting A. 3944 and Engineering. J 336

Draughtsmen Required, for

Aeronautical work, preferably with experience of Aeroplane construction. No one on Government work need apply.—Apply, your nearest EMPLOYMENT EXCHANGE, stating age, experience and salary required, and mentioning No. A 3867. J 417

Draughtsmen Required for

High-class Aero Engine Design. Good prospects for the right men. Experience in internal combustion engine desirable. Apply, stating full particulars and salary desired, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 318. No person already engaged on Government work need apply.

Wanted Chief Draughtsman

and Engineer, having a thorough practical knowledge of Gas Producers, Gas and Coal Fired Furnaces. Competent to take charge of Drawing Office, estimate, draft specifications, and conduct correspondence. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning thi Journal and J 549.

Wanted, Capable Draughts-

MAN with knowledge of general engineering for works in Richmond district, able to adapt himself to a speciality. State age, previous experience and salary required. Only those not already engaged upon Government work, and residing within a ten-mile radius need apply.—Address, J 563, Offices of Engineering.

Wanted, One or Two First-

class DRAUGHTSMEN, thoroughly experienced in high-class instruments design, for important Government work.—Address, giving full particulars of qualifications, stating wage required and when at liberty, J 444, Offices of Engineering.

Draughtsmen Wanted, for

Power Station Work.—Apply, stating age, experience and wages required, to ELECTRICITY OFFICES, Town Hall, Bradford. J 543

Draughtsmen for Electrical

machines and control gear, steam turbines and steam layouts.—Applicants must have good mechanical knowledge, and should send full particulars including age and salary required to their nearest EMPLOYMENT EXCHANGE, mentioning this Journal and A 4089. J 427

Wanted, Immediately, by a

large Engineering firm in the Midlands, a first-class General DRAUGHTSMAN, preferably one with experience in heavy machine tools and general plant work. No one employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 516.

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large Engineering firm in the Midlands, a first-class JIG and TOOL DRAUGHTSMAN. Must have had first-class experience in the design and execution of all classes of jigs used on ordnance and machine tool work. No one employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 517.

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to Works Lay-out. No one resident more than ten miles away or already on Government work will be engaged.—Reply, stating age, salary required and give details of past experience, to BOX 426, T. B. Browne's Advertising Offices, 163, Queen Victoria Street, E.C. 4. J 566

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Elevator and Conveyor experience and used to automatic machine design. No one residing more than 10 miles away or already on Government work will be engaged.—Reply, stating age, salary required, and give full details of past experience to BOX 425, T. B. Browne's Advertising Offices, 163, Queen Victoria Street, E.C. 4. J 565

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Wanted, Three Draughtsmen

with thorough knowledge of modern blast furnace construction for a new blast furnace plant.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4033. No person already engaged on Government work will be considered. J 462

Wanted, Good Junior and

Senior Marine or Mechanical Engineering DRAUGHTSMEN. Must be men of particular ability. State practical and scientific training, age and salary required. No one already on Government work need apply.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4047. J 443

Required, for Dover, Good

General DRAUGHTSMAN, with knowledge of steelwork and ferro-concrete construction. Must be ineligible for general military service.—Apply by letter, stating age, full particulars of experience, salary required and enclosing copy of recent testimonials, to BOX No. 897, care of Street's, 8, Serle Street, London, W.C. J 431

Two Draughtsmen Wanted,

with mechanical and electrical experience. Accustomed to factory work. Excellent prospects to the right men. London District. State age, experience and salary expected.—Address, J 509, Offices of Engineering.

Draughtsman, Structural, used

to reading stress diagrams and working from engineers' calculations and sketches; good salary and prospects. No one residing more than ten miles away or already engaged on Government work need apply. Ex soldier preferred.—Write, BOX 22, care of Crosley & Co., Ltd., 57, Coleman Street, E.C. 2. J 499

Draughtsmen. — Wanted, in

London. Three capable DRAUGHTSMEN for By-product Coke Oven work; also One for Ferro-Concrete work. Good salaries paid to capable men. No one at present employed on Government work or resident more than ten miles away will be engaged. Applicants must be of British nationality.—Address, J 520, Offices of Engineering.

Wanted, Draughtsman, with

transformer experience. Nobody employed on Government work will be accepted.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4086 and Engineering. J 539

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PYROMETERS AND PYROMETRY.

(*Concluded from page* 528.)

We now conclude our notice of the meeting of the Faraday Society held on November 7.

Optical Pyrometry in Metallurgy.

The contribution to the discussion, made by Professor F. G. Donnan, F.R.S., of University College, London, on "Optical Pyrometry in Non-Ferrous Metals" was timely, because it emphasised certain essential, but sometimes overlooked, features of the problems of metallurgical pyrometry. He said that his remarks might really be entitled "Optical Pyrometry and Corrections to be Applied." When the radiation issuing from a hole was sighted, the conditions of "full radiation" (black-body radiation) were fulfilled; but when an open bath or stream of metal was observed, correction had to be applied. In the case of molten copper and gold, the appearance of an open bath differed much more from full radiation than in the case of steel. These fused metals afforded a beautiful sight; copper looked bluish green, gold green. The two metals had a strong selective reflection when cold not changing very much with temperature. The relation between selective emissivity and selective reflectivity was given by Kirchhoff's law: $E_1/E=A$, where E_1 was the emissivity of the substance, E the emissivity of a full radiator at the same temperature, and A the absorptivity—all for some particular wave-length λ. The quotient E_1/E or absorptivity might also be called "relative emissivity." If R were the reflectivity, then $E_1/E=A=1-R$. As regards solid and liquid copper, gold and silver these relations had been investigated with the aid of a spectrophotometer by Drs. Stubbs and Prideaux in Professor Donnan's laboratory (then at Liverpool). Plotting the E_1/E or A against λ (from 0.45 μ to 0.7 μ) and making temperature determinations by means of thermocouples they found a sharp discontinuity in the emissivity at the melting points (a fact questioned by previous observers); the liquid gold emitted more in the red and yellow, and less in the blue, than the solid; and the curves for the liquid and solid metals were quite different, but no temperature coefficient of relative emissivity was discovered for the liquid metal over a range of 100 deg. C. Similar relations held for copper; fused silver had a very low emissivity all through the range. The relation between apparent temperature and true (black-body) temperature was not simple, and had to be referred to a definite wave-length λ; the true temperature was that of a full radiator (black-body) emitting light of the same intensity as the substance, the formula being:

$$\frac{1}{T}-\frac{1}{S_\lambda}=\lambda \log e\, A_\lambda / c_2$$

where S_λ was the black-body temperature, T the true temperature on the absolute scale, A_λ the relative emissivity, and c_2 a constant. As the λ decreased from 0.784 μ to 0.416 μ, the black-body temperature of solid gold at its melting point rose from 891.5 to 1025.5, and of the liquid gold from 931 deg. to 1019 deg. C. Similarly with copper; as the wave-length decreased from 0.7 to 0.5, the black-body temperature of the solid copper at its melting point rose from 896 deg. to 1,028 deg., and that of the liquid copper from 717 deg. to 1,026 deg. The accepted thermocouple melting point of gold was 1063.2, that of copper 1083.4, and of silver 960.7 deg. C. (Day & Sosman). The experiments were conducted in reducing atmospheres; incipient crystallisation of the liquid and polishing difficulties of the solid were among the disturbing factors, and the use of glasses, which were not monochromatic as assumed, probably accounted for the divergent observations of Burgess on copper. In using an optical pyrometer the light should always be observed at right angles to the surface; otherwise it would be polarised, Professor Donnan concluded.

The Pyrometry of Ferrous Metallurgy.

In his "Notes on Pyrometry from the Standpoint of Ferrous Metallurgy," Dr. W. H. Hatfield, of the Brown-Firth Research Laboratory, Sheffield, pointed out that most metallurgical operations had to be performed within certain temperature limits, but ready reliable means of determining those temperatures were hardly available. As regards steel melting, optical pyrometers would, for instance, give the temperature of the slag or of the roof and walls of a furnace, but that did not teach us the temperature of the metal actually lying on the hearth. He had recently made some experiments. Sighting the optical pyrometer on steel running into the ladle, he observed temperatures of 1,400 or 1,410 deg. C. When a thermocouple was placed in the empty ladle before the steel was running in, the curve rose to a flat maximum as the ladle was filling, and descended again when it was emptying; the maximum was at 1,600 deg. C. or 1,625 deg. C. These temperatures might be incorrect, since extrapolation above 1,400 deg. was uncertain, but the great difference between the two readings suggested questions such as a possible change in the emissivity of steel with conditions independent of temperature. A 0.1 carbon steel froze at 1,480 deg. to 1,485 deg., in accordance with the iron-carbide diagram. In their reheating experiments, platinum couples and an optical pyrometer (Cambridge) were used; the temperature of a mass of steel inside the furnace would, by the pyrometer, be recorded by 60 deg. or 100 deg. higher than that of the same steel outside the furnace, owing to imperfect black-body conditions in the latter case. In rolling and forging the hot surface was cooled by coming in contact with the cold hammer and dies, and the surface might hence appear to be at 900 deg., whilst the ingot, cut in two, would indicate 1,000 deg. In annealing and other operations much depended upon the manner in which the couple was placed relative to the steel. For low-temperature work, at any rate, base-metal couples (silver-constantan, nickel and nickel-chrome) had also proved reliable.

The time required for heating-up masses of steel varied with the nature of the material, its shape and dimensions, and the "diffusivity"—rate of heat penetration—depended upon thermal conductivity, specific heat, density, and, further, upon the heating medium and the surface condition; there seemed to be a very steep gradient at the skin, and the critical points further complicated such investigations. According to J. A. Harker the specific heat of nearly pure iron increased from 0.1175 at 200 deg. C. to 0.1647 at 850 deg., decreasing slightly at higher temperatures; but the data available for various steels were very meagre. Thermal conductivity could be determined in various ways. The method which A. Johnstone had recently described to the Physical Society for determining changes in the conductivity of materials when under stress was very simple: a known amount of heat was applied to the middle of a wire whose ends were cooled to a constant low temperature, and the gradient was measured. On this principle Dr. Hatfield had, at the laboratory, tested bars of 1 cm. diameter with the aid of copper-eureka thermocouples. Over the range 10 deg. C. to 40 deg. C. they had found the values A and B for thermal and electric conductivity:—

	A	B
Wrought iron...	100	100
0.9 carbon steel, as rolled ...	55.3	58.4
25 per cent. nickel steel ...	25.8	12-25
Air-hardened nickel-chrome, steel as rolled	40.6	34.5
High-speed steel, as rolled ...	38.0	36.2
High-speed steel, hardened ...	28.8	17.2

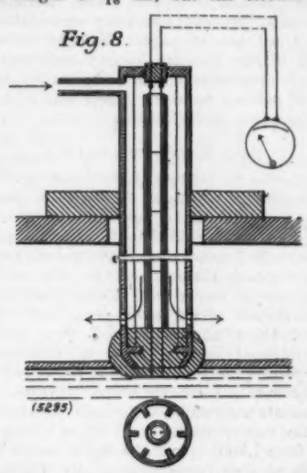
The results showed, in agreement with the experiments of Jaeger and Diesselhorst, that the parallelism between thermal and electric conductivity was only approximate. Much research was needed in this field.

Dr. Hatfield was questioned by Mr. Johns as to the wave-length used, which he did not remember, and Professor Donnan doubted whether such metallurgical investigations were always conducted with the necessary knowledge of physics.

Called upon to open the general discussion on these metallurgical papers, Dr. J. A. Harker said that they had, at the National Physical Laboratory, by no means neglected the importance of the glass for the eyepieces of optical pyrometers, nor had Mr. Whipple. Glasses differed very much, even in the same samples sometimes, and it was very difficult to determine which was the dominant wave-length. Another difficult point was the size of the object; the optical pyrometer should only be applied to big objects, but they had, in the standardising laboratory, not hundreds of tons of fused steel to work with. Mr. Rhodin regretted that optical pyrometers like polarmeters were too much subject to personal errors.

Dr. F. Rogers, of Sheffield, described a new type of thermocouple of his own. The ends of the couple had refractory material (clay or moulder's composition) moulded about them and firmly into contact with, and even over, the end of the sheath (Fig. 8). The wire-ends were not united to a hot junction, but were placed in contact with the molten metal. A perfectly steady reading was instantly obtained, and the pyrometer could be withdrawn before the stem was damaged by the heat, although in actual tests of several minutes' duration the pyrometers had not failed. The tip was alone heated to the temperature to be measured; possibly the wires melted or alloyed with metal over a length of $\frac{1}{8}$ in., but the electric circuit

Fig. 8.



remained continuous. The air entered the sheath near the head and blew out through holes a little above the end; the cold-junction trouble was avoided by placing the cold-junction inside the sheath near the air-blast inlet. He had not yet made a thorough calibration of his pyrometer, and the following temperatures were merely calculated from the resistance ratios: solidification of cobalt-chrome high-speed steel in crucible, 1,530 deg. C.; solidification of copper in open furnace, 1,062 deg.; temperature in a 70-ton open-hearth steel furnace during melting down, 1,450 deg. In these trials the end of the pyrometer was actually immersed in the metal, for 3½ minutes in the last case, in which the stem was 9 ft. long, air-cooled, and clad with heavy clay sleeves. The first development of these couples had been made in conjunction with Messrs. P. R. Kuehnrich and J. F. Kayser in the Spartan Steel Company's works at Sheffield, and in Messrs. Taylor Brothers' Steel Works, Leeds. Immersion of the pyrometer tip for from 2 seconds to 10 seconds was sufficient and a layer could be ground off the tip if contamination were suspected.

Dr. Rosenhain feared that such a couple would not last long; the platinum-rhodium would soon become contaminated. The difficulty of the general problem was to measure what one really wanted; the pyrometer inside the furnace did not give that unless one placed a dummy, provided with a hole to take a thermocouple, next to the object in the furnace. That was not always possible, and the future seemed to be with some pyrometer outside the furnace. The thermal conductivities of various steels differed very much, and Dr. Hatfield would find his penetration tests very difficult; Dr. Griffiths and he (Dr. Rosenhain) had recently evolved a method for measuring the thermal conductivities of aluminium-alloys.

Mr. W. Carter, while almost grumbling that pyrometers were so cheap, that one could not trouble the manufacturer about their use, complained also that they were too delicate; the man in the hardening shop did not want tiny screws and scales to be read with a magnifying glass. Mr. Whipple replied that instruments were often very badly used, and when they were said to be burnt through, they were

really broken. Hardeners and others wanted special limited ranges. Considering that metallurgists now asked for instruments correct within 2 deg., pyrometry had certainly advanced. The coloured glasses, supplied now practically by one American firm, were a source of great trouble. Mr. Peddle spoke on behalf of the glass makers, who could rarely use thermocouples, as they were attacked by the glass and contaminated the glass. He found optical pyrometers best; the radiation pyrometer of Foster was fairly good, but its life was not very long. In Mesuré instruments the personal equation, he agreed with Professor Arnold, was awkward; when one worked round the holes of a furnace, and returned to No. 1 again, the reading would be different.

Summing up the discussion in a few words, Sir Richard Glazebrook remarked that a conference between Messrs. Whipple Johns, McCance and the National Physical Laboratory seemed desirable.

The third set of papers brought before the meeting of the Faraday Society dealt with base metal pyrometers and with temperature measurements of pottery materials; their was no time for their discussion, unfortunately.

Base-Metal Pyrometers.

Mr. Charles R. Darling, A.R.C.S., of the City and Guild Technical Institute, Finsbury, in presenting a short communication on base-metal thermo-electric pyrometers said that the couples commonly used were iron-constantan, two iron-nickel alloys of different compositions, and two different nickel-chrome alloys known as Hoskins alloys; some iron-aluminium alloys were also used. Though some of these alloys changed their properties with continued heating, some of British manufacture were quite reliable within prescribed limits, but they were not reliable above 1000 deg. C. If liquid metals were utilisable, metals like aluminium, silver, tin, copper, nickel, iron, whose boiling points ranged from 1,800 up to 2,450 deg. C. would become available at high temperatures. Mr. Darling suggested how that might be done. Experimenting with Mr. A. W. Grace on the electromotive forces of fused metals (on which problems Mr. Darling has recently made communications to the Physical Society), he had found that with most metals there was a continuous rise in the E.M.F. as the temperature rose, and that there was no change in the trend of the curve, which was practically a straight line, at the melting point of the metal (except in the cases of bismuth and antimony). To utilise this properly he fixed two silica tubes into holes drilled into a block of carbon, 1 or 2 in. square so far, inserted rods of different metals in the tubes, screwing the ends into the carbon to ensure better contact if necessary, connected the four ends to a nickle voltmeter, and inserted the block and tubes vertically into the furnace up to a certain level. There would be difficulty with the refractory material to be adopted for the tube in practice, and with the expansion of the freezing metals; but his experiments, so far only at temperatures up to 1,000 deg. C., were promising. The graphite block prevented the mixing of the metals, whilst the E.M.F. was the same as if they were in actual contact.

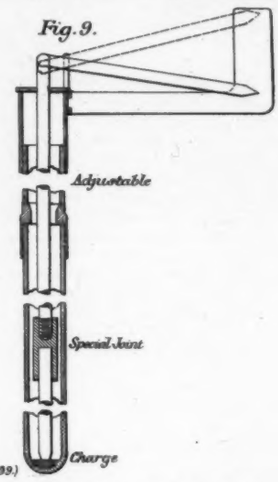
Behaviour of Base-Metal Couples.

Mr. G. E. M. Stone, head of the pyrometry department of Messrs. Armstrong Whitworth and Co., contributed some very interesting "Notes on the Remediable Causes of Unreliability encountered in Thermoelectric Pyrometry, especially in systems of the Base-Metal Type." Among the requirements which he claimed for base-metal couples was a reliability within 10 deg. C. That could often be obtained; but when more than one instrument were in use, combined with various recording instruments, some couples and fire-rods or "stems" would behave peculiarly. Readings passably correct at first, fluctuated by 50 deg. after a few hours; and when rectification was effected by adjusting the compensating resistance, the former error might either be found to have rectified itself, so that the adjustment was unnecessary, or some other source of error made its appearance. When appeals were made to the manufacturer, the representative might find the erratic instrument apparently in good order. With the assistance of Mr. H. R. S. Johnson, Mr. Stone had investigated the causes of these troubles. The non-homogeneity of the materials was a first serious obstacle to their working. Iron-constantan couples e.g., which were much in use, failed owing to particular changes at the critical points, and when the furnace temperature was not uniform or the rates of heating and cooling were varied, the readings fluctuated. It was the same with nickel. The heterogeneity could be demonstrated by cutting a couple, which had been in use, longitudinally in halves, joining the cold ends to a millivoltmeter, crossing the former hot ends at various spots, perhaps an inch apart, and heating these new junctions. Owing to this want of homogeneity the "cold-junction error" was quite an uncertain quantity as well, and that could not be cured by compensating leads. Mr. Stone had many instructive exhibits exemplifying faulty materials, junctions, insulations, &c.

In fire-rods, in which one element of the couple surrounded the other in the form of a tube, two faults were often noticed at an early stage. The central wire was electrically welded to the tip of the tube; the two materials had different expansions coefficients, and the friction between the insulating sheaths of fireclay or porcelain and the wire was often sufficient to force the tips out from the weld. Secondly, the central wire was frequently overheated during the welding and turned spongy and mechanically weak. A cure could be effected by adopting small beads of fire-clay for the insulation. A common fault of all couples (not only of base-metal) was that the ohmic resistance of the two parts was not rigorously of the same value. In one installation they had found the tested terminal resistance of a considerable number of the same instruments to range from 2.67 to 5.3 ohms, no two being alike. Such instruments would give different readings for the same temperature. The principal source of error was, however, that the terminal resistance of the measuring instrument was made too small. In such a case an imperfect contact, a little dirt getting between the contacts at the head of the fire-rods, or between the prongs of an electric switch, an addition to the length of the leads by a few inches, wires getting locally hot by radiation from the furnace or by lying on the ground, might set up appreciable errors. When the total resistance of the pyrometer was about equal to that of the recording instrument, which was not an unusual feature, an increase of the connection resistance by 0.12 ohm might lower the reading by 15 deg. C. In this particular case the resistances had been the following: 9 ft. fire-rod 0.46 ohm, furnace leads 0.14, wires to recorder 3.0 ohms, making external resistance 3.6 ohms; instrument 3.6 ohms; total resistance of circuit 7.2 ohms; E.M.F. generated at the tip of the fire-rod at 800 deg, 35 millivolt. Plotting these figures in a potential-fall diagram, it would be seen that the E.M.F. initially indicated would fall to half its value, 17.5 millivolts during the passage of the current along the resistances. But the instrument was calculated to indicate that temperature of 800 deg. at the tip of the rod, and the movements of the needle were really given the value of $\frac{1}{17}$ of 800 deg., i.e., 46 deg. per millivolt at that part of the scale. Mr. Stone then showed in detail how a change in the external circuit by 9.12 ohms would affect the reading as stated, whilst with an instrument resistance of 400 ohms the difference would amount to 0.24 deg. only. Instead of high-resistance recorders, however, heavy leads were adopted, and to shorten them the instrument was placed near the furnace. Warping wooden bases for instruments and their leaning against masses of iron, which caused magnetic leakage, were other remediable causes of trouble; vertical needles with depressors bearing against pads, which varied in moisture, were also objectionable; hollows developed in the depressor and caught the needles; and the central hole of circular charts was not accurately punched. Again in concentric connection for the heads of fire-rods the central connection and its insulation were not sufficiently secured sometimes. All these minor errors, though individually small, were apt to accumulate. Finally Mr. Stone strongly advocated high-resistance recorders though they were of more delicate construction than low resistance instruments with substantial pivots and control springs.

The pyrometer of Messrs. E. M. Stone and W. B. Barclay, one of the exhibits, stands quite apart from ordinary pyrometers and deserves a name of its own. It is an instrument designed for the purpose of indicating whether the time for pouring a particular metal of known composition has arrived; this purpose is, of course, sufficiently useful. The instrument is of the stem pattern (Fig. 9). The tube consists of two parts; the lower portion is a silica tube closed below; the upper portion an open brass tube, the

Fig. 9.



junction being effected by means of slots and set screws for adjusting the design. The rod inside the tube is also two-part; the lower portion consists of fused silica, the upper of an iron rod; the silica rod is cemented into the junction piece which is slotted to allow for expansion; the iron emerges through the cap of the tube and is joined above to a lever. The silica rod now—this is the chief feature—rests on a mass of metal or alloy (the charge) placed in the bottom of the silica tube, the metal being the same as that which is to be melted in a crucible. The stem is inserted into the crucible; when the metal there fuses, the charge in the stem also fuses and the rod in the stem sinks, forcing the lever up. To prevent the silica rod from being caught by the solidifying charge, the lever is pressed by a spring catch into a recess and held there; the charge thus solidifies level and the instrument is ready for re-use. A sheath is pushed over the lower end of the stem to prevent contamination of the silica tube with clay. This pyrometer is made by Mr. Samuel Platts, of Sheffield.

Pyrometers of Pottery Materials.

Mr. Henry Watkins, of Stoke-on-Trent, contributed a paper on "The Measurement of High Temperatures by Means of Pottery Materials," the only communication dealing with pottery materials. He pointed out that every class of pottery and porcelain, the clays, bodies, glazes, colours, lustres, &c., had its own particular maximum and minimum degree of firing. To observe those degrees was very difficult because the materials differed very much as to contraction, fusibility and other properties. The contraction of fireclays he had tested varied from 8 per cent. to 5.3 per cent. at 960 deg. C., and from 14.3 per cent. to 8.5 per cent. at 1,180 deg. The colour of natural felspars gave some clue as to their fusibility, as Mr. Watkins' numerous exhibits exemplified, and the potters of past centuries had had other guides, such as changes in the colours of the flames and of the products, translucency, touch, and the ringing of the fired goods when struck together, guides which had by no means lost their value. The first pyrometer of the potter Josiah Wedgwood, described by him before the Royal Society in 1782, had relied on the contraction of wedges of clay. Since 1900 clay discs, each with a pole through the centre, had come into use; the disc was withdrawn from the fire by means of a hook

and measured accurately against a steel gauge. Buller's trial rings were based on the same principle. They were clay rings, 2½ in. in diameter, registering on the gauge plate; the ring contracted, the changes were noted on special charts, and a check was thus obtained on the time of firing and on the work of the man in charge of the furnace. Voight and Light, of Paris, had first made use of the fusibility of clay, felspar, &c., for temperature control. Out of that had grown the cones of Seger, 1886, ranging in melting or softening-points from 1,150 deg. to 1,390 deg. C., and of Cramer (range 590 deg. to 1,130 deg. C.). Messrs. Holdcroft and Co. had, in 1898, replaced the cones by their thermoscope bars; four of those bars were as a rule supported in step-fashion in a refractory case; they sagged when softening, and the sagging was more easily observable than the collapsing of the cones. Thermocouples were now made in numbers from 1 up to 59, and also distinguished by letters A, B, C, D, E, F, the highest numbers and letters referring to thermoscopes for research and temperatures up to 2,000 deg. C.

Mr. Watkin's own "recorders" and "discoverers" were of a similar type. The recorder was a slab of very refractory ware which was provided with five circular recesses in the top face; in each recess was placed a pellet of some material of a definite melting-point; a wrapper which afterwards burned away retained the pellets in their recesses. A "discoverer" was a recorder with 15 instead of 5 pellet holes, reading from 590 deg. up to 1,270 deg. C., the slab dimensions being about 2 in. by 1 in. Many of these cheap meters were placed in different parts of the furnace to maintain the temperature within the necessary limits which were rather narrow frequently. Thus a coral red glaze or lustre would be good at 670 deg. or 690 deg., faulty at 710 deg., and completely spoiled at 730 deg. C. The bright liquid gold would not adhere to the glaze at 650 deg., would be good at 670 deg. and be spoiled at 710 deg.; a manganese glaze, purple at 950 deg., would turn brown at 1,050 deg., and chrome yellow would change into green within the same temperature-range. The limitation of these pyrometers was that they did not register the period during which the respective temperatures were maintained. Hence, contraction tests were not superseded; but those tests again were not perfect either, small objects contracted relatively more than large objects, and there were other difficulties.

Instruments Exhibited.

In addition to the novelties already described, a considerable number of instruments were exhibited during the meeting. The Cambridge Scientific Instrument Company had a large display. Their optical pyrometer, so often mentioned in the discussion, is a kind of polarising photometer. The observer compares two beams; the one comes from the object under test, the other from a small 4-volt carbon lamp; both beams pass through a system of lenses and prisms, are polarised and rendered monochromatic, and the common eyepiece shows a field divided into two semicircles; the two are matched by turning the eyepiece, the pointer of which travels over the scale; the instruments are fitted with one or two scales. As the accuracy greatly depends upon the constancy of the small lamp, provision is made for standardising this lamp —outside the works—against an amylacetate standard. The indicators, portable or wall-type, of the Cambridge Company are moving-coil galvanometers of robust construction and high internal resistance, 1,200 ohms in one suspended instrument exhibited, the scale of which has a length of 7 in. A novel convenience is the mechanical set-up due to Messrs. Hirst and Rowcliffe, of the firm, a device allowing the observer to start, *e.g.*, at 500 deg. C., instead of at 0 deg., in a scale reading up to 1,100 deg.

The thread recorder is a clock-driven instrument in which the pointer of the suspended-coil galvanometer is depressed at intervals so as to trace a dotted temperature curve on a drum which may be set to make one revolution in 25 hours or in 2 hours 5 minutes. The new style exhibited is fitted with a double-thread frame giving two threads of different colours; a rocking mechanism brings either frame alternately under the galvanometer boom, and with four thermocouples four records (in two colours) are obtained; the wipe contacts for changing over from one colour to the other have been displaced in the new instruments by mercury contacts made in an airtight ebonite tube. We should also mention the Whipple indicator, a Wheatstone bridge recommended for standardising thermocouples; the bridge is balanced by turning a handle and gives direct temperature readings. The ends of the base-metal couples of the Cambridge Company are now made renewable.

The exhibits of the Foster Instrument Company, of Letchworth, which makes use of Hoskins' alloys in their thermocouples, comprised a cold-junction box filled with oil. We also mention the depressor of their portable recording pyrometer, because these devices, which are of general use, were repeatedly referred to during the discussion. The chart is a circular disc, 10 in. diameter, in front of which the marking pen swings freely, to be depressed overy ½ minute by the bar; the pen takes up its ink from a pad on the pressed bar which the clockwork rotates. Mr. Robert W. Paul, of New Southgate, N., also had a large number of exhibits. The Wild-Barfield steel-hardening furnace, exhibited by Automatic and Electric Furnaces, Limited, of 6, Old Queen-street, S.W. 1, was described on page 71 of our issue of July 20 last.

KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE.

(*Continued from page* 485.)

We continue our illustrations of this interesting bridge by giving on Plate LIII with this issue details of the nose end of the centre truss of the Scherzer roller lift span. The main drawings are a continuation of those of the rear end on Plate XLV published with our issue of 2nd inst. As we stated in that article and as is well shown by the perspective views Fig. 61 on page 552, and Fig. 62 on Plate LII the trusses are of the Warren type, with vertical subsidiary posts at each panel point. They are of 18 ft. effective depth at the nose end and 36 ft. at the rear end.

Fig. 63, Plate LIII, is an elevation, with cross-sections of the main members; Figs. 64 and 65 are plans of the top and bottom of the bottom boom respectively, and Figs. 66 and 67 show the bottom and the top of the top boom. The bottom boom is 2 ft. 4½ in. deep by 1 ft. 8 in. broad between web plates. The web plates are $\frac{5}{8}$-in. thick, and the main angles are 6-in. by 4-in. by $\frac{5}{8}$-in., while the area is further increased by $\frac{5}{8}$-in. side plates as the stresses increase towards the centre and rear end of the truss. The boom is open at the bottom, so that there is no lodgment for water, but both the top and bottom edges are braced by 6-in. by 3½-in. by ½-in. diagonal angles and 2-ft. by ½-in. by 2-ft. 5½-in. tie-plates, as illustrated in Figs. 64 and 65, Plate LIII, plate and angle diaphragm at the cross girders, as described above, and two diaphragms in each bay, consisting of ⅜-in. plates connected to the boom by 3½-in. by 3½-in. by ⅜-in. angles, as shown in Fig. 63, Plate LIII. This bracing is necessary, since there are compressive stresses in the bottom boom when the span is raised.

The top boom is 2 ft. 0½ in. deep by 2 ft. 6 in. wide over all. The main angles are 6 in. by 4 in. by $\frac{5}{8}$ in., the side plates or web are $\frac{5}{8}$-in., reinforced by $\frac{5}{8}$-in. plates as required by stresses. There is a top plate, which varies in thickness from $\frac{5}{8}$ in. to ½ in. to suit stresses. The bottom edge of the boom is braced with angles and tie-plates, and diaphragms are provided both at the panel points and between them to stiffen the side plates as in the bottom boom.

The field joints in the top and bottom boom are made at the panel points and are suitably covered, as shown on illustrations.

For the same reason as stated for the bottom boom the diagonals of the main truss are all designed as struts. Each is of the same form, consisting of four angles with side webs, braced at top and bottom with lacing angles and tie-plates. Where necessary, the area is increased by additional side plates. Member U_1—A_1, Plate XLV, published with our issue of the 2nd inst., may be taken as an example. It consists of four angles 6 in. by 4 in. by ⅝ in. and two side webs 2 ft. by ⅝ in., and is further reinforced by four side plates 1 ft. 10 in. by $\frac{5}{8}$ in. and two side plates 1 ft. 3½ in. by ⅝ in. The bracing top and bottom is of 6-in. by 3½-in. by $\frac{5}{8}$ in. angles laced at 60 deg., terminating in ½-in. tie plates. Five ⅝ in. plate diaphragms further stiffen the webs. Each end of the diagonal is attached to the large ⅞-in. double gusset plates at the panel points. The vertical posts at U_2, U_4 and U_6, which divide the panel lengths of the top boom, consist of two 12-in. by 3½-in. 26.1 lb. channels laced with 2½-in. by ⅜-in. flats. Those at U_3, U_5 and U_7, which act primarly as hangers from the cross girders to the panel points, are built-up members, consisting of four angles 6 in. by 4 in. by $\frac{7}{16}$ in., and a 1-ft. 6½-in. by ½-in. web plate. That at U_1 is of slightly heavier section owing to the change of inclination of the bottom boom.

The tops of the trusses are braced together by four portal trusses, one of which was illustrated in detail on Plate XLV with our issue of the 2nd inst. Others are at the panel points marked U_2, U_5 and U_7 on Fig. 63, on Plate LIII. We give details of the portal at the nose end.

This end portal truss connecting the sloping end posts is illustrated in Fig. 68, Plate LIII. It is built up of double 6-in. by 4-in. by ⅝-in. angles braced together with double 4-in. by 3-in. by ⅝-in. diagonal angles and double 3½-in. by ½-in. by ⅜-in. vertical angles, with two 4-in. by 4-in. by ⅝-in. angles for centre vertical. All are connected with ½-in. gussets. Between the portals horizontal cross-bracings 2 ft. 0½ in. deep, of 6-in. by 4-in. by $\frac{9}{16}$-in. angles, are provided from truss to truss as illustrated at the panel points U_2, U_5, &c., in Fig. 67, Plate LIII. These are connected to cross struts between top booms above bottom panel points, as at U_1 in Fig. 63, Plate LIII, and are illustrated at the same point in Figs. 66 and 67. They are made up of double angles 5-in. by 3½-in. by ⅝-in. top and bottom, braced together with lacing flats and connected to the top and bottom of the top boom by ⅜-in. gusset plates. The cross braces also serve to shorten the effective length of the top booms when the latter act as struts. Short longitudinal braced girders, 2 ft. 0½ in. deep, are provided in the overhead bracing, midway between the main trusses, as shown on the elevation, and the connections of two of these to the end portal trusses are shown in Figs. 69 and 70, Plate LIII. They consist of double 6-in. by 3½-in. by ⅝-in. angles top and bottom, braced together with 2½-in. by ½-in. flats.

The arrangement of the riveting at the panel point A_1 (Fig. 35) on Plate XLV with our issue of the 2nd inst., where the truss members meet the end of the rolling segment, may be of interest as showing the heavy class of riveting required both in shopwork and at the site, in this type of bridge.

The cross girders, of which there are nine, are hung from the bottom of the trusses. At the bottom panel points, as at L_4 and L_5, the ¾-in. gusset plates are extended down around the web of the cross girder, to which they are connected by 4-in. by 4-in. by ½-in. by 2-ft. 8½-in. angle cleats, and in addition a plate diaphragm between the bottom boom is provided to which the cross girder is attached by double covers. The rivets through the connections are 1 in. diameter. Below the top panel points, as at L_3 and L_4, the cross girder is attached to the vertical post, which transmits the load to the panel point, by heavy cover plates. Double ¾-in. gusset plates are also provided, riveted to the bottom boom, which serve to stiffen the cross girders fore and aft.

The deck on both railway and highway portions is of ⅜-in. flat plates stiffened by angles, and riveted to the cross girders and longitudinal and bottom booms of main trusses. This flooring, the guard rails, and the method of retaining the permanent way are similar throughout the bridge, and will be described later when dealing with the fixed spans.

This arrangement of overhead trussing, with the plated deck and the rigid connections to the ballast box extending across the full width of the bridge produced an exceptionally well braced and rigid structure.

A close boarded fence reaching to 6 ft. 8½ in. above the bottom boom is provided between the railway and highway. This is shown in part elevation

TABLE I.—CALCULATED COUNTERWEIGHT REQUIRED AT EACH STAGE, ASSUMING A WIND VELOCITY OF 80 MILES PER HOUR (20 LB. PER SQ. FT.), AND THAT THERE IS NO PRESSURE ON THE STRUTS UNDER THE QUADRANT OR PULL ON THE RACK GIRDER. THE COUNTERWEIGHT IS ASSUMED TO BE SPREAD EVENLY UPON THE BACK OF THE BALLAST BOX.

Case.	Direction of Wind.	Moments.		Counterweight.			Remarks.
		Dead Load.	Wind.	Dead Load.	Wind.	Total.	
1	From right ..	667 tons × 11.3 ft.	$\frac{3,900 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 45 ft.	7,537 ÷ 14 ft.	1,560 ÷ 14 ft.	− 538 and − 111	This does not include for permanent way, railway, or roadway, floor plating, hand-rails or machinery.
		= − 7,537 ft.-tons	= − 1,560 ft.-tons	= − 538 tons	= − 111 tons	= 649 tons	
	From left ..	Do.	= + Do.	= − 538 tons	= + 111 tons	= − 538 and + 111 = 427 tons	
2	From right ..	772 tons × 14.7 ft.	$\frac{5,000 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 64 ft.	11,348 ÷ 14 ft.	2,659 ÷ 14 ft.	− 810 and − 204	Do. do.
		= − 11,348 ft.-tons.	= − 2,859 ft.-tons	= − 810 tons	= − 204 tons	= 1,014 tons	
	From left ..	= − Do.	= + Do.	= − 810 tons	= + 204 tons	− 810 and + 204 = 606 tons	
3	From right ..	873 tons × 18.3 ft.	$\frac{6,100 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 83 ft.	15,976 ÷ 14 ft.	4,537 ÷ 14 ft.	− 1,141 and − 324	Do. do.
		= − 15,976 ft.-tons	= − 4,537 ft.-tons	= − 1,141 tons	= − 324 tons	= 1,465 tons	
	From left ..	= − Do.	= + Do.	= − 1,141 tons	= + 324 tons	= − 1,141 and + 324 = 817 tons	
3A	From right ..	873 tons × 18.3 ft.	$\frac{6,100 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 83 ft.				This does not include for permanent way, railway, or roadway, handrails, or Machinery; but a portion of floor plating, &c., is included.
		12 tons × 33 ft. Panel 1	$\frac{790 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 35.5 ft.	16,372 ÷ 14 ft.	4,786 ÷ 14 ft.	− 1,169 and − 342	
		= − 16,372 ft.-tons	= − 4,786 ft.-tons	= − 1,169 tons	= − 342 tons	= 1,511 tons	
	From left ..	= − Do.	= + Do.	= − 1,169 tons	= + 342 tons	− 1,169 and + 342 = 827 tons	
3B	From right ..	873 tons × 18.3 ft.	$\frac{6,100 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 83 ft.				
		12 tons × 33 ft. Panel 1.	$\frac{790 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 35.5 ft.				
		11.1 tons × 35.8 ft. Panel 2	$\frac{765 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 56 ft.	16,769 ÷ 14 ft.	5,169 ÷ 14 ft.	− 1,198 and − 369	Do. do.
		= − 16,769 ft.-tons	= − 5,169 ft.-tons	= − 1,198 tons	= − 369 tons	= 1,567 tons	
	From left ..	= − Do.	= + Do.	= − 1,198 tons	= + 369 tons	− 1,198 and + 369 = 829 tons	
3C	From right ..	873 tons × 18.3 ft.	$\frac{6,100 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 83 ft.				
		12 tons × 33 ft. Panel 1	$\frac{790 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 35.5 ft.				
		11.1 tons × 35.8 ft. Panel 2	$\frac{765 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 56 ft.				
		11.1 tons × 38.6 ft. Panel 3	$\frac{765 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 75.5 ft.	17,197 ÷ 14 ft.	5,685 ÷ 14 ft.	− 1,228 and − 406	Do. do.
	From left ..	= − 17,197 ft.-tons	= − 5,685 ft.-tons	= − 1,228 tons	= − 406 tons	= 1,634 tons	
		= − Do.	= + Do.	= − 1,228 tons	= + 406 tons	− 1,228 and + 406 = 822 tons	
3D	From right ..	873 tons × 18.3 ft. = 15,976	$\frac{6,100 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 83 ft. = 4,537				
		12 tons × 33 ft. = 396	$\frac{790 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 35.5 ft. = 249				
		11.1 tons × 35.8 ft. = 397	$\frac{765 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 56 ft. = 383				
		11.1 tons × 38.6 ft. = 428	$\frac{765 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 75.5 ft. = 516				
		11.1 tons × 41.4 ft. = 460	$\frac{765 \text{ sq. ft.} \times 20 \text{ lb.}}{2,240}$ × 95 ft. = 649	17,657 ÷ 14 ft.	6,334 ÷ 14 ft.	− 1,261 and − 453	Do do.
	From left ..	= − ft.-tons 17,657	= ft.-tons − 6,334	= − 1,261 tons	= − 453 tons	= 1,714 tons	
		= − Do.	+ Do.	= − 1,261 tons	= + 453 tons	− 1,261 and + 453 = 808 tons	

at the nose end of span, Fig. 63, on Plate LIII, while details of the steel framing for the same are continued throughout this view.

We may now describe the work of building the Scherzer roller lift span, which as already described was effected vertically, and thus there was no obstruction of the river traffic during the construction. Figs. 72 to 75 on Plate LIV are illustrations from photographs taken at successive stages of the work.

For the erection of the rolling lift span two 15-ton steam cranes were placed covering the job, and in such relative positions that they could act together for the heavier lifts. The half of each track girder was first assembled on its flat and the centre joint riveted by a hydraulic riveter. The two halves were up-ended, steel and cast-iron blocks inserted, the halves brought together and bolted, and the end and bearing plates riveted in place; finally each girder was skidded into position and lowered to its grillages, which previously had been set with the greatest care. The cross girders and bracings were assembled on blockings in their position ready for connections to be bored after the track girders had been aligned. The alignment of the three track girders was carried out with the greatest possible accuracy. After all parts were assembled, the centre line of the south or "A" track girder was given by a theodolite set up on the land span and sighted to the centre of the bearing block of the corresponding girder of the lift span resting on pier No. 2. The track girder was set to this line, plumbed and securely fastened to grillages. Afterwards the other two girders were set off from this as base, by cross and diagonal measurements by tape.

Finally the connections of the cross girders and the bracings were drilled and riveted, the flooring plates, &c., added and the structural steelwork completed. Lastly the cast-steel track plates were placed and aligned and squared-off accurately from the same base line by wires stretched with a constant weight. When all was set, holes for bolts were drilled with a battery of four pneumatic drills, the bearing surfaces coated with red lead, and the track plates bolted down.

The segmental girders were then assembled in a similar manner to the track girders, the two parts of each half segment being first assembled on the flat, the centre joint riveted, and the piece up-ended and assembled with the corresponding half in their position on the track on a section of track plate, the remaining track plates added, and the diaphragms riveted. Temporary angle bracings were then added to keep the segments in proper alignment one to the other until the ballast box and first portal bracing were built and riveted. The segments were allowed to take their natural position on the tracks.

Afterwards the ballast box was built, and by its weight it gradually rolled the segments back until the box rested on the stop blocks provided for it on the east land span. Lastly, timber struts, two to each segment, were added, from the track to the segments, and any slight variation in the height of the point of the segments above the tracks was carefully adjusted. Daily check measurements of the alignment of the segments were made until the main parts of the ballast box and portal were riveted. The erection of the span then proceeded, firstly by means of a 15-ton crane lifted to the top of the ballast box. This was used as far as it would reach, and then there was erected another 15-ton crane on a staging built on the steelwork, and by the latter the erection was finished to the point of the span. These successive stages are illustrated by Figs. 72 to 75, on Plate LIV.

As the erection proceeded concrete ballast was added from time to time in the counterweight box to keep the balance with a preponderance for stability in the vertical position. Table I and diagrams, which are reproduced in Figs. 76 to 78, were prepared

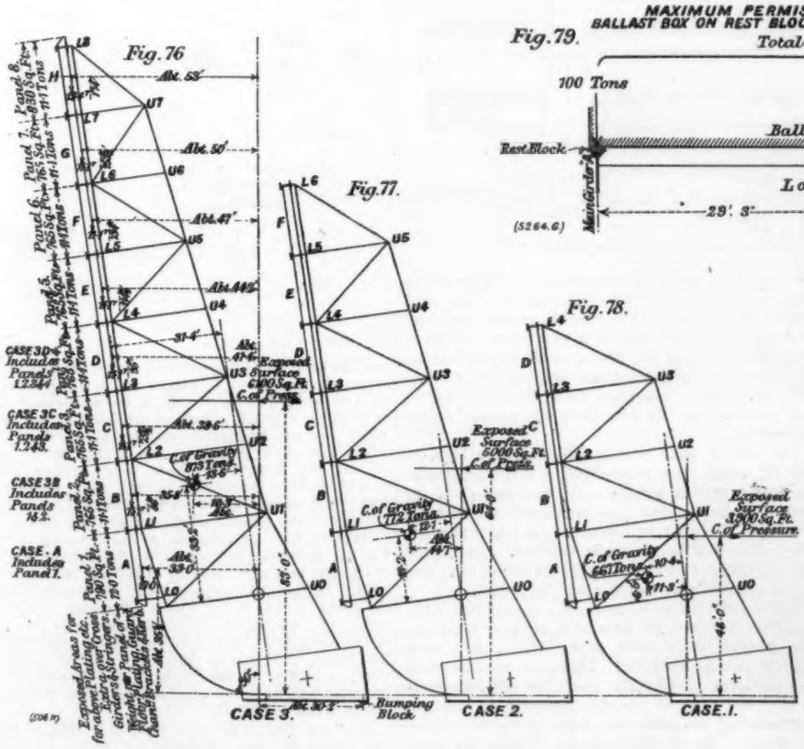
TABLE II.—THE RESULTING MAXIMUM PRESSURES ON THE BUMPING BLOCKS FROM THE WIND ON THE UNDERSIDE OF THE BRIDGE, PLUS THE DEAD LOAD.

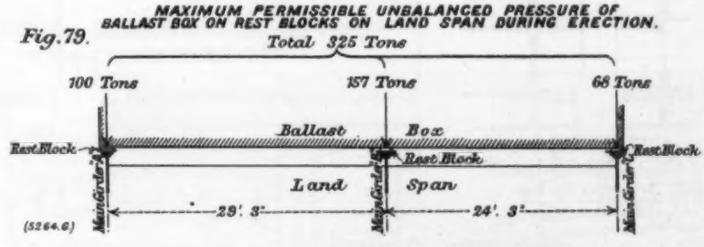
Case.	Direction of Wind.	Moments.			Counterweight Due to			Unbalanced Moment.	Pressure on Bumping Blocks.	Condition.	Remarks.
		Dead Load.	20 Lb. Wind.	Counter-weight.	Dead Load.	20 Lb. Wind.	Total.				
		ft.-tons.	ft.-tons.	ft.-tons.	tons.	tons.	tons.	ft.-tons.	tons.		
1	No wind ..	− 7,537	—	+ 9,097	538	111	649	1,560	÷ 30.2 = 51.6	Dead load only. No floor plating ..	
	From left ..	− 7,537	+ 1,560	+ 9,097	538	111	649	3,120	÷ 30.2 = 103.2	Dead load and wind. No floor plating	
1A	No wind ..	− 7,933	—	+ 9,742	567	129	696	1,809	÷ 30.2 = 60.0	Dead load only. 1 panel of plating ..	
	From left ..	− 7,933	+ 1,809	+ 9,742	567	129	696	3,618	÷ 30.2 = 120.0	Dead load + wind. 1 panel of plating	
1B	No wind ..	− 8,330	—	+ 10,522	595	157	752	2,192	÷ 30.2 = 72.5	Dead load only. 2 panels of plating ..	
	From left ..	− 8,330	+ 2,192	+ 10,522	595	157	752	4,384	÷ 30.2 = 145.0	Dead load + wind. 2 panels of plating	
1C	No wind ..	− 8,758	—	+ 11,466	625	194	819	2,708	÷ 30.2 = 90.0	Dead load only. 3 panels of plating ..	
	From left ..	− 8,758	+ 2,708	+ 11,466	625	194	819	5,416	÷ 30.2 = 180.0	Dead load + wind. 3 panels of plating	
1D	No wind ..	− 9,218	—	+ 12,575	658	240	898	3,357	÷ 30.2 = 111.1	Dead load only. 4 panels of plating ..	
	From left ..	− 9,218	+ 3,357	+ 12,575	658	240	898	6,714	÷ 30.2 = 222.2	Dead load + wind. 4 panels of plating	
2D	No wind ..	− 13,029	—	+ 17,685	931	332	1,263	4,656	÷ 30.2 = 154.0	Dead load only. 4 panels of plating ..	
	From left ..	− 13,029	+ 4,656	+ 17,685	931	332	1,263	9,312	÷ 30.2 = 308.0	Dead load + wind. 4 panels of plating	
2E	No wind ..	− 13,519	—	+ 18,957	965	389	1,354	5,438	÷ 30.2 = 180.0	Dead load only. 5 panels of plating ..	
	From left ..	− 13,519	+ 5,438	+ 18,957	965	389	1,354	10,876	÷ 30.2 = 360.0	Dead load + wind. 5 panels of plating	
2F	No wind ..	− 14,041	—	+ 20,395	1,003	452	1,457	6,354	÷ 30.2 = 210.4	Dead load only. 6 panels of plating ..	
	From left ..	− 14,041	+ 6,354	+ 20,395	1,003	452	1,457	12,708	÷ 30.2 = 420.8	Dead load + wind. 6 panels of plating	
3F	No wind ..	− 18,669	—	+ 26,701	1,333	574	1,907	8,032	÷ 30.2 = 266.0	Dead load only. 6 panels of plating ..	Total Exceeds counterweight.
	From left ..	− 18,669	+ 8,032	+ 26,701	1,333	574	1,907	16,040	÷ 30.2 = 532.0	Dead load + wind. 6 panels of plating	

Maximum pressure on bumping blocks not to exceed 325 tons.

TABLE III.—DATA AS TO COMPLETED BRIDGE, INCLUDING ALL PERMANENT WAY FOR RAILWAY AND ROADWAY.

Case.	Direction of Wind.	Moments.			Counterweight Due to			Unbalanced Moment.	Pressure on Bumping Blocks.	Pull on Racks.	Condition.	Remarks.
		Dead Load.	20 Lb. Wind.	Counter-weight.	Dead Load.	20 Lb. Wind.	Total.					
		ft.-tons.	ft.-tons.	ft.-tons.	tons.	tons.	tons.	ft.-tons.	tons.	tons.		
Special	No wind ..	− 45,360	—	+ 45,360	1,781	—	1,781	0	None	0	Bridge complete	Rack pinion under repair.
Do.	From left ..	− 45,360	+ 10,368	+ 45,360	1,781	—	1,781	+ 10,368	÷ 30.2 = 343.0	0	Do.	
Do.	From right ..	− 45,360	− 10,368	+ 45,360	1,781	—	1,781	− 10,368	÷ 28.0 =	370 (approx.)	Do.	Bridge open.





NOTE.—In calculating the exposed surfaces the wind has been assumed to blow at a slight angle to the axis of the bridge so as to take effect on top and bottom booms and web members. To allow for this assumption and for any negative pressures the following values were taken:—Twice the area of top flanges at right angles to the axis of the bridge, 1½ times the width of cross girders and stringers and the actual exposed areas of ballast box and machinery platform. The centre of pressure has been assumed to be in the centroid of the calculated surfaces.

The weights given at the centre of gravity do not include for:—Counterweight, permanent way of railway rails, timber and cement concrete); permanent way of roadway (timber, decking and expansion plates) [floor plating, guard channels, brackets and kerb = 91 tons total], handrails, locking gear, buffer and operating machinery.

previous to the erection and show the required minimum amount of ballast to balance the dead load plus a 20-lb. wind pressure in either direction at the various stages. Three definite stages of the erection are shown in Figs. 79, 80 and 81, with their respective centres of gravity and centres of wind pressure. In Fig. 79 the variations due to the addition of the floor plating in the four lower panels are given. Table I shows the calculated amount of counterweight required for the various stages due to the wind, or dead load separately. Table II shows the resulting maximum pressures on the bumping blocks, from wind on underside of the bridge plus dead load, assuming the gudgeon and pinions are not connected to the rack girder frames.

After investigation it was found that the main girders of the land span carrying the bumping blocks were capable of carrying a concentrated load of 325 tons on the blocks (Fig. 79), in the place of the usual live load; this determined the permissible amount of ballast that could be placed in the counterweight box at this stage. Before the erection reached a stage shown by Case 2D the gudgeon and pinions were connected with the rack girder frames so that any further pressures due to wind were carried down to the rack frame anchorages. From Table III will be seen the maximum pressure on the bumping blocks when the racks are under repair, or the maximum horizontal force on the gudgeon pins, when the bridge is completed and all permanent way and decking is in position.

The actual weight of ballast in the counterweight box is about 1,800 tons, space being left on the box for considerable adjustment, the ballast is made up

with about 1,600 tons of slag concrete, weighing 162 lbs. per cubic foot, and 200 tons of old rails, &c. The weight of the leaf excluding ballast is 1,120 tons, and the total rolling weight of the complete bridge is about 2,920 tons.

While dealing with the erection of the lifting span it may be well to describe the setting out of the machinery, although a detailed description of it will not be given until later. As is well known in this type of opening bridge, the operating pinions are located at the axis of rotation of the rolling segments. Thus the locus of travel of these pinions is in an horizontal plane, the track plates, on which the segments roll, being horizontal. The second condition for the setting out, which follows from the first, is that the racks with which the main pinions engage, must also be horizontal. The setting of the racks was taken in hand first. There are two of these racks, one on each side of bridge. That on the upstream side is shown in the perspective view in Fig. 43, Plate XLVI with out issue of 2nd inst. As shown, the rack, with its supporting girder, is carried on two vertical posts, whilst the longitudinal stresses which amount to 370 tons with a 20-lb. wind are taken by diagonal struts meeting at the centre. A field joint was provided at the top of each post and each post was made ¼ in. long. The posts were first erected and completely riveted to the track span. Vertical measurements were then made from the surface of the track plates, and the posts cut to the correct height. The rack girders were erected, the cover plates drilled, and the job bolted up. It was estimated that the track and segmental girders would deflect ¼ in. under the rolling load of the lifting span. This would have caused the pinions to sink deeper into gear by the same amount at the centre of track span, if the rack girders had been left horizontal. Therefore, before drilling the cover plates for the diagonal struts, the rack girders were drawn down in the centre until they had a reverse camber of ¼ in., and were then secured in that position. Finally, riveting was completed.

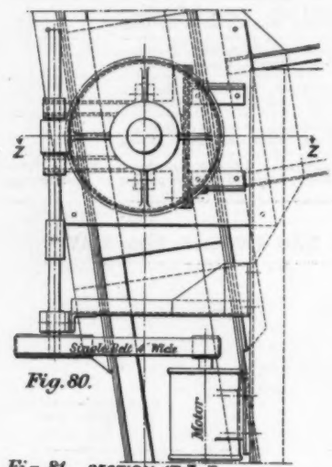
Later, the racks, which were in sections 6 ft. long, were aligned on the rack girders in the usual manner, being set parallel to the centre line of the track plates. They were secured to the girders by fitted bolts. It is important that these bolts should each take their proper share of the high stresses which come on the racks when the span is lifted in high winds. To attain this, the first section next the river was set and bolted down, and the other sections, after alignment, were drawn tight up to the first by means of large folding wedges placed at the land end of the racks, so that the machined ends of the rack sections made a perfect butt before the bolt holes were drilled. These wedges were permanent and served to transfer the rack stresses down the supports to the piers.

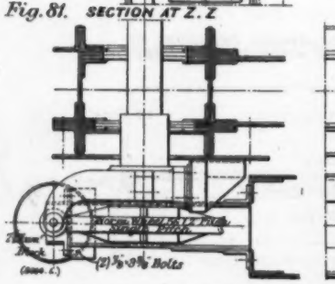
In dealing with the machinery on the lifting span, the centre of rotation was first scribed on A and C—the outer—girders, from the machined surface of the rolling segments, by means of a trammel 28 ft. long. A wire, stretched from side to side of the bridge through these two points, formed the base line from which all the machinery on the lifting span was set. The two main pinions are each carried on a gudgeon pin turning in bearings fixed to A and C girders and the heavy portal steelwork between them and the centre or B girder. Holes had been provided for these bearings, but were left ¾ in. small in diameter, to be bored out to the true diameter at the site, from the scribed centre of rotation.

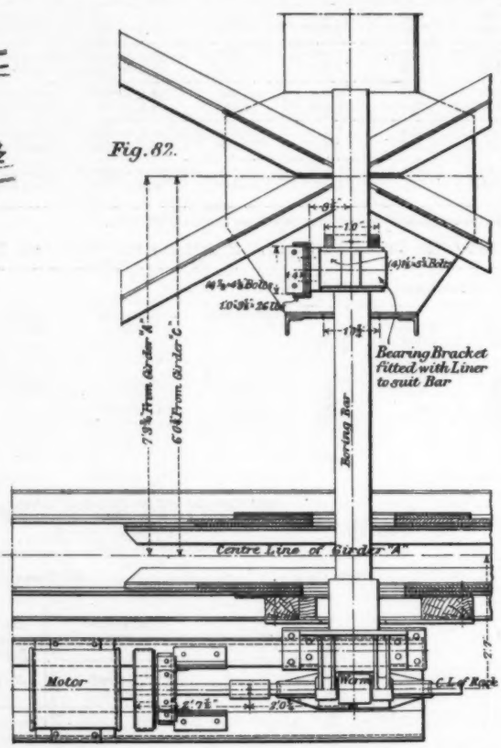
The boring gear used is illustrated in Figs. 80 and 81, which show respectively a side elevation of the gear, a vertical section, and a sectional plan. As shown, a boring bar was supported on suitable bearings. This bar was driven by a motor through a belt drive and worm and wormwheel. The boring bar was centred on the scribed axis of rotation, and bored out the holes to the exact diameters.

Afterwards, the main gear, &c., was set out in the usual manner from the axis of rotation as base line. The motors, differential gear, brakes, &c., were located on one platform. This gear was fitted on the platform in Glasgow and was self-contained, so that the work at the site consisted in the true alignment of the platform—a comparatively simple operation. As we have already stated we shall later on describe all the gear in detail.

(To be continued.)





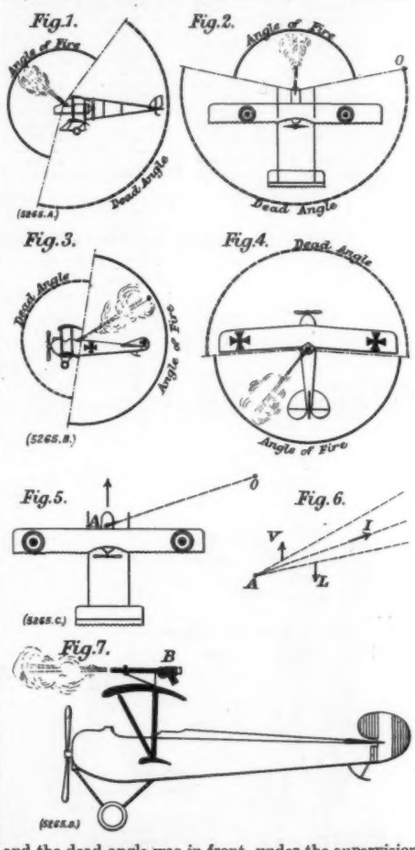


American Concrete Ships.—According to *The Marine Journal*, New York, the American Cement Ship Company is contemplating the establishment of a line of cement steamers to ply between Boston and South America.

THE ARMAMENT OF AEROPLANES.

In an article published in the French journal *La Nature* on the "German Technics of Aerial Armament," the author, after reviewing the characteristic features of the different classes of aeroplanes, speed, manageableness, armament, altitude, &c., states that armament remains the decisive factor in an aerial fight.

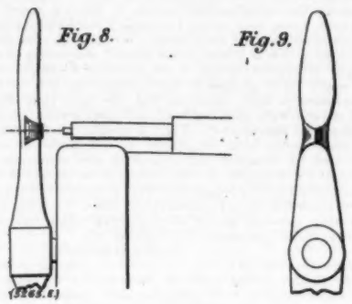
At first the aeroplanes were simply armed with a rifles; then they were made to carry quick-firing guns fitted on an extempore mounting. Most of the French machines being of the "pusher" type had, as shown in Fig. 1, which illustrates a Farman 1915 machine, a considerable dead angle in the rear which greatly facilitated surprise attacks. Moreover, the quick-firing gun being mounted on a pivot in front of the nacelle, made it difficult to defend the aeroplane on the sides (Fig. 2). The German aeroplanes being "tractor" machines, carried their quick-firing guns in the rear

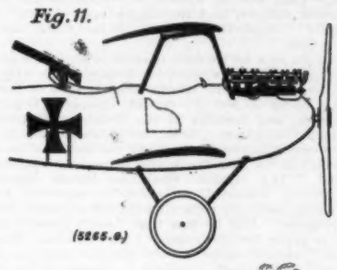


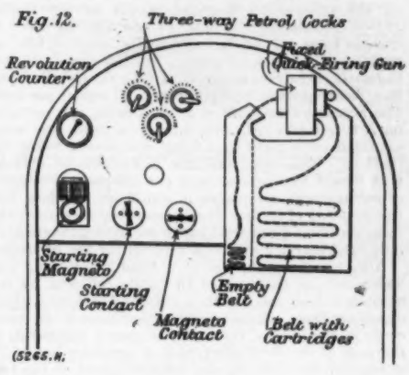
and the dead angle was in front, under the supervision of the pilot, as shown in Figs. 3 and 4, which illustrate an Aviatik 1915 machine. There was in the early days of military aviation a lack of precision in the firing, which was due to several causes. In the first place, errors were made in aiming, due to the relative speed of the two machines; there were, further, errors caused by the vibrations of the guns themselves, which were of too light a build; and also errors attributable to the difficult position which the gunner had to take to fire—for example, in the direction of O in Fig. 2. Moreover, difficulties surrounded the working of the gun in a wind velocity of 100 km. (62 miles) per hour. Further, the trajectories of the rounds fired in the direction of O in Fig. 5 were influenced by different forces, i.e., the lateral initial velocity due to the speed of the aeroplane (force V in Fig. 6), the side wind on the bullet, also due to the speed of the aeroplane (force L in Fig. 6), two forces V and L which, compounded with that representing the initial velocity I, modified the trajectory.

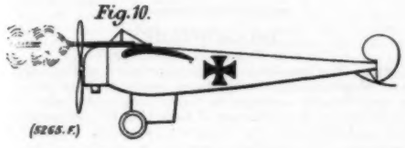
The next period in aerial warfare is that in which the armament was organised on board aeroplanes specialised in regard to the missions they had to fulfil. Three main arrangements were adopted, both in France and by the enemy: (1) Fixed quick-firing guns, firing in front above or through the propeller (single-seaters); (2) fixed quick-firing guns, one as in the former instance, to which was added a second gun mounted on a turret for astern firing (two-seaters); (3) front firing by a quick-firing gun mounted on a turret, astern firing by a similar gun, and firing below

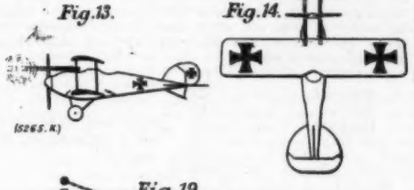
THE ARMAMENT OF AEROPLANES.

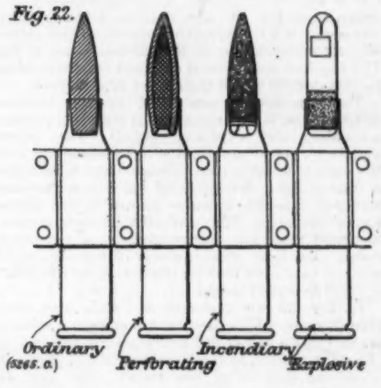


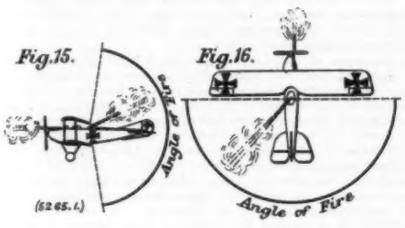


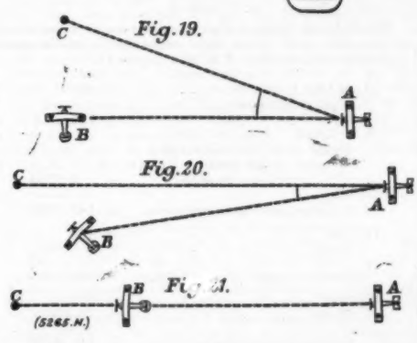


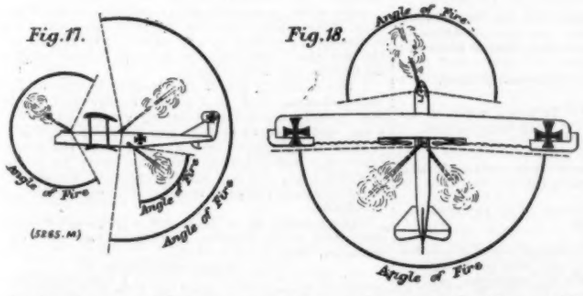












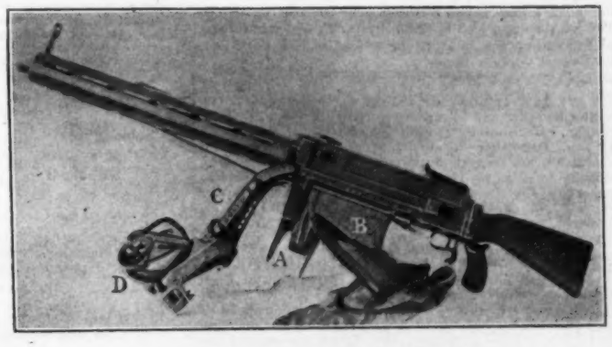


FIG. 23. PARABELLUM MACHINE GUN.

FIG. 24. MAXIM GUN.

the fuselage by a quick-firing gun mounted on a pivot (three-seaters).

The Nieuport chasing biplanes were the first to mount a fixed quick-firing gun to fire above the propeller (see Fig. 7). The main disadvantage of mounting the gun in this position, besides the great air resistance it offered, was the difficulty of feeding the ammunition. The pilot had to pivot the gun down to remove the empty disc and replace it by a fresh one containing 47 rounds, and these were rapidly expended when firing at the rate of from 300 to 400 rounds per minute. The difficulties were such that the pilot of the first Nieuport machines was compelled to abandon a fight when he had not obtained a decisive result with his first disc of cartridges. Garros was the first to fire a fixed quick-firing gun through the propeller. The gun was worked at its normal speed, and two very hard steel sleeves (Figs. 8 and 9) were fitted in the propeller blades, forming passages for the bullets. The number of balls which struck the sleeves and were lost amounted to less than 7 per cent. or 8 per cent., a negligible quantity. But this method was rapidly abandoned, since it entailed a loss of speed of about 20 km. (over 12 miles) per hour. Owing to the transformation the propeller lost a part of its tractive force. The Germans mounted a fixed quick-firing gun firing through the propeller on their chasing Fokker of 1915–16 (see Fig. 10). The gun fires through the propeller, but it is combined with the engine and its firing is synchronous with the working of the engine. The governing of the gun by the engine is effected by a rigid gear (Fokker, Albatross D. Halberstadt, &c.) or by flexible gear (Albatross C. Rumpler C). The pilot starts firing at will by acting upon a Bowden lever. The application of synchronous firing with the running of the engine has been adopted on most of the French and enemy machines. The gun is sheltered by the engine bonnet, as illustrated in Fig. 11, which shows part of an Albatross 1917. It is easily supplied with ammunition and thrown out of gear. The cartridge magazines can contain belts of 800 to 1,000 rounds. They are illustrated in Fig. 12. The German series of Albatross D1, D3, Halberstadt, Roland D, Ago D, and Fokker D have each two fixed quick-firing guns firing through the propeller, each supplied with 1,000 rounds. Figs. 13 and 14 show the chasing Albatross 1917.

Another type of armament, used for two-seater and less fast machines, whose duty is to regulate gunfire, to take photographs and to carry out bombardments on a small scale, is shown in Figs. 15 and 16, which illustrate the angles of fire of an Albatross C, 1917. The series comprises the Albatross, Rumpler, Aviatik, L.V.G., all machines of class C, two-seaters, having a speed of 140 km. to 160 km. (87 miles to 100 miles) per hour. Their armament is defensive; a quick-firing gun forward fires through the propeller; the rear quick-firing gun is mounted on a turret. A similar arrangement has been adopted in France.

The front gun is similar to those in use by the infantry; the rear one is much lighter.

A further type of armament is that which is provided on the three-seater aeroplane, such as the Gotha, 1916–17, illustrated in Figs. 17 and 18. In order to free the front part of the fuselage the machine has two engines and two propellers. In this series are the Gotha G, Friedrichshafen G, A.E.G. G, and Rumpler G. Their speed is about 150 km. (93 miles) per hour. The armament consists of a quick-firing gun movable on a turret forward, and one aft, a third gun being mounted on a pivot and firing downwards below the fuselage. This large machine is difficult to attack; it is bound to develop, since the adequate protection of medium-size aeroplanes is a difficult problem, and the bombing of centres at a distance becomes more and more a necessary undertaking for paralysing the enemy's industrial activity and as a reprisal for his barbarity.

Although the adoption of a fixed quick-firing gun which fires in the axis of the route followed by the aeroplane does away with a part of the forces which disadjust firing, all these difficulties have to be overcome in the case of the movable guns; moreover, in the case of the fixed guns, lack of precision has to be accounted for owing to the relative speed of the two machines. The correction required is an important one if the two machines fly perpendicularly to each other, as in Fig. 19; the machine A has to aim at C, the angle B A C giving the extent of the correction. The correction is less in Fig. 20 and is nil in Fig. 21. The required correction is obtained by means of special aiming devices which cannot yet be described.

The ammunition now used by the Germans is illustrated in Fig. 22; it contains ordinary, perforating, incendiary and explosive bullets. The incendiary bullets are hollow and filled with an incendiary material the basis of which is phosphorus; these bullets produce a trail of light, the object of which is to fire airships and petrol tanks, and also to enable the gunner to correct his range. The perforating bullets consist of a hardened steel core surrounded by a German-silver cover. The belts contain about 10 per cent. or 15 per cent. of explosive bullets, the action of which is that of small explosive shells.

In Fig. 23 we illustrate a Parabellum gun the references to which are the following: A, side roller for carrying a belt of 250 cartridges; B, bag into which the empty cartridge cases are ejected; C, jointed fork; D, rolling support on the turret. The gun weighs 12 k. (26.4 lb.); with 250 cartridges and accessories the weight is 32 k. (70.5 lb). A Maxim gun is shown in Fig. 24, in which A is the synchronising device with the engine and B the Bowden grip regulating firing. The gun weighs 13.3 k. (29.3 lb); with 500 cartridges, and including the support the weight is 36 k. (79.3 lb.).

The Institution of Water Engineers.—The winter meeting will take place in the Geological Society's Rooms, Burlington House, Piccadilly, London, on Friday, December 7, at 2.15 p.m. There will be a discussion on Water Supplies as Sources of Power, opened by Mr. C. H. Roberts, M.Inst.C.E., and two papers on the theory and practice of air-lift pumping by Mr. C. Anthony, M.Inst.C.E., and Mr. A. H. Jameson respectively.

Gas for Industrial Purposes.—Mr. Harry Jones, in his presidential address to the Institution of Civil Engineers, delivered on the 6th inst., said that Sir Robert Hadfield had stated that in his Sheffield works he used as much as 500,000,000 cub. ft. of gas per annum for smelting and metallurgical purposes; that figure represented the output of 45,000 tons of coal. Mr. Jones added that Mr. Hanbury Thomas, the manager of the Sheffield Gas Company, had stated that his company had no less than 642 furnaces, consuming 372,000,000 cub. ft. of gas, at work in his district, while 15,116 h.p. gas engines consumed 789,000,000 cub. ft.

Honours to Naval Engineers.—The King has been graciously pleased to approve of the award of the following honours to Navy engineers, among others:—(*a*) For services in action with enemy submarines: To receive the *Distinguished Service Cross*—Engineer-Lieutenant W. B. McDonald, R.N.R. (since killed); to receive the *Distinguished Service Medal*—Engine-Room Artificers R. J. Ballantyne and W. Swapp; to receive a Bar to the *Distinguished Service Medal*—Engineer Lieutenant-Commander W. A. Carlisle, R.N., Engineer-Lieutenants L. J. Jeffrey, R.N.R., and F. W. Axtens, R.N.R., Acting Engineers A. H. Benfield, R.N., and F. H. Knowles, R.N., and Engine-Room Artificer P. R. Blacklock. (*b*) For services in the mercantile marine: To receive the *Distinguished Service Cross*—Chief Engineer O. H. Jelley; *Commended*—Chief Engineer B. W. Newton. The King of Italy has conferred *Silver Medals for Military Valour* upon Engineer-Commanders W. C. Johnson, R.N., and G. H. Soullard, R.N., Engineer-Lieutenant-Commander Morgan, R.N., Engineer-Lieutenant Mck. Dallas, R.N., and Chief Engine-Room Artificers G. G. Hill and J. Searle; and *Bronze Medals for Military Valour* upon Chief Engine-Room Artificer T. W. Hole and Engine-Room Artificer T. J. Oliver.

TERMS OF CONTRACT.

To the Editor of Engineering.

Sir,—Your leading article of September 21, on this important subject, and the suggestions of your correspondents "Shipbuilder" and "M.Inst.C.E." are very appropriate.

It should be a very simple matter to adopt the proposal to institute a bonus system for employers as well as for workmen, and it seems strange that an idea of this kind did not occur to Mr. W. Rowan Thomson, Director of machinery, and member of the Merchant Shipbuilding Advisory Committee; who, as an employer, has had unique opportunities of studying the merits of premium systems. He is also the writer of a recent publication entitled "The Rowan Premium Bonus System of Payment by Results," in which he expresses himself most enthusiastically regarding the virtues of the methods he advocates. If it be true that "what is sauce for the goose is sauce for the gander" the "Rowan Premium System" should afford a very effective solution of the "Terms of Contract Problem." There is no cogent reason why the proposed basis of contract suggested in your issue of October 5 by "M.Inst.C.E." should not be adopted,* and the following figures may be used to illustrate how "The Rowan Premium System" might be used. It does not affect the question whether the ratios are correct, and therefore we may take those undermentioned, namely:—

		£	
Material ...	...	60	
Labour ...	...	40	
On-cost ...	...	40	= (10 per cent. on M and L,
Profit ...	...	10	or 7 per cent. on M, L, O).
Total ...		150	

Examples 1, 2 and 3 show a reduction of 5 per cent., 10 per cent. and 15 per cent. respectively on the total expenditure in respect of M plus L plus O.

		£
(1) M plus L plus O	=	140
5 per cent reduction	=	7
Cost	=	133
Profit £7 per cent. plus 5 per cent. £9.31 plus £0.4655 ...	=	9.7755
Contract price plus premium...	=	142.7755
(2) Cost	=	126
Profit	=	9.702
Contract price plus premium	=	135.702
(3) Cost	=	119
Profit	=	9.5795
Contract price plus premium...	=	128.5795

The above scheme is on all fours with the Rowan plan in operation in connection with the remuneration of labour, and even the formula is similar, thus in place of:

$$\frac{\text{Time taken} \times \text{time saved}}{\text{Time allowed}} = \text{premium (hours)},$$

say $\frac{50 \times 50}{100} =$ 25 hours, which at 1*s.* per hour = 25*s.*

Substitute—

$$\frac{\text{Cost} \times \text{saving}}{\text{Estimated}} = \text{premium (per cent. of estimated profit)},$$

say $\frac{70 \times 70}{140} =$ 35 per cent. of £7 per cent. = £2.45

But as an alternative to the foregoing another scheme might be suggested, namely, to pay the profit agreed upon plus a premium, as shown by examples (4), (5) and (6).

		£
(4) M plus L plus O	=	140.0
5 per cent reduction ...	=	7.0
Cost	=	133.0
Profit = 10*l.* plus 5 per cent. ...	=	10.5
Contract price plus premium ...	=	143.5
(5) Cost	=	126.0
Profit = 10*l.* plus 10 per cent. ...	=	11.0
Contract price plus premium ...	=	137.0
(6) Cost	=	119.0
Profit = 10*l.* plus 15 per cent. ...	=	11.5
Contract price plus premium ...	=	130.5

Yours faithfully,

Golder's Green, N.W. W. J. Grosart.

FARADAY SOCIETY PYROMETRY DISCUSSION.

To the Editor of Engineering.

Sir,—In your otherwise admirable summary of my paper, on "The Determination of the Temperature of Liquid Steel under Industrial Conditions," I am made to suggest that the difference in results obtained by Burgess in American steel works and myself here "was probably due to the glass which Burgess used," and it might be inferred that I had criticised Burgess. Nothing was further from my mind. Burgess used glass of 0.65 μ, which is the best wave-length to employ in optical pyrometers, as is well known. Owing to circumstances which were explained by Mr. Whipple at the meeting the instruments which I, among some other workers, have been using for some time employs 0.70 μ, which is an unusual wave-length for this purpose and not the best. When I found out that I was using a wave-length of approximately 0.70 μ it was a simple matter to apply the necessary corrections to the observed temperatures and, allowing for the fact that Burgess and myself were dealing with different steels, we are in substantial agreement. That I should have been able to trace what was originally a difference in results obtained by Burgess and myself to the employment of unusual wave-length in the instruments supplied to me rather confirms my suggestion that the apparent temperatures recorded in my paper were observed with a considerably greater degree of accuracy than one would expect under industrial conditions.

Yours very truly,

November 18, 1917. Cosmo Johns.

[Mr. Cosmo Johns spoke of the valuable investigations by Dr. Burgess, but we certainly also understood him to say, at the end of his remarks, that the glass might be at fault in cases in which he did not agree with Dr. Burgess.—Ed. E.]

* Except that part which proposes to penalise the contract in the event of the fixed price being exceeded. No shipbuilder or engineer the writer has ever known would agree to this.

DRAUGHTSMEN.

To the Editor of Engineering.

Sir,—The formation of the Association of Engineering and Shipbuilding Draughtsmen seems to have come as a considerable surprise to many employers, who seem to think the draughtsman is forfeiting his independence and individuality by adopting a policy of banding together. The present tendency of modern drawing-office administration seems to be towards crushing individualism, and making men automatic.

It is a peculiar fact that in the small firms a man has individual freedom, and must have high qualifications, and accept large responsibility, although he has to be content with a small salary.

In some of the large firms he has little or no individuality, has less responsibility, receives a larger, but not necessarily adequate salary, and has to submit to irritating conditions. A young man entering a small company's drawing office full of energy and future hopes, is given the best work he can do, and encouraged to be self-reliant. He foregoes salary, thinking by thus obtaining sound experience he will eventually find a good position elsewhere. Upon obtaining this relatively better-paid position in the larger firm he finds that what is required is output in drawings. A man's ability cannot be measured by terms of lines drawn, a showy drawing may have involved little brain power, whereas a less involved looking design may have taken careful thought, and scientific ability to produce.

After a few years of the above experiences the draughtsman, if fortunate, branches out into some other department offering more scope, or otherwise in disgust accepts the inevitable, and ceases to attempt further progress in his professional attainments.

I think that much of the trouble is due to lack of understanding, and that if the commercial gentlemen who usually control engineering companies will make a real endeavour to be just, and estimate the true value of their draughtsmen, taking into account the amount of experience and scientific study necessary to produce a qualified man, and pay him accordingly, our differences could be easily adjusted without seriously affecting their dividends.

Draughtsmen as a class are a reasonable body of men, and given justice, employers can rely on fair demands, and loyal service.

Yours respectfully,

"A Draughtsman."

To the Editor of Engineering.

Sir,—I notice that letters from various draughtsmen (particularly in your issue of November 9) advise the Association of Engineering and Shipbuilding Draughtsmen to become a trade union and definitely ally themselves with Labour. By doing this they would only perpetuate the present very prevalent idea that a draughtsman is a man who pushes a pencil about to someone else's orders. A competent draughtsman (designer would be a better term) works almost entirely with his brain, and if he is ever to get any recognition of the fact must insist on describing himself as a professional man. I will take my own case, that of a leading draughtsman in a Government Department, as it is probably typical of many others. I get, perhaps, a sketch showing a rough rectangle with one or two irregular circles distributed about it, and three or four dimensions added, and am instructed to get out a contrivance (I hope this term is vague enough to pass the Censor) to perform some specified function. I very probably have to rough out the general design myself while supervising the working out of details and preparation of shop drawings by others. I require a good knowledge of the processes employed in manufacture, and I must figure out the stresses produced when necessary, and I frequently have to make use of the higher branches of mathematics, and figure out special cases for myself.

If I have not considerable scientific knowledge my design is bound to suffer, and I require imagination and judgment enough to carry out my preliminary work on broad and flexible lines or I shall be frequently compelled to begin again owing to difficulties encountered later on. The qualities sketched above are those required of a professional man, and we shall be throwing away the substance for the shadow if we do not contend

for our rightful position as brain-workers. Nothing less will do us any permanent good, though a succession of strikes and disturbances might bring us a few more shillings a week in the present, coupled with a black outlook in the future.

What we stand in need of is a society requiring a high standard of efficiency and general engineering knowledge in its members (without which the draughtsman is a nuisance to his chief and a danger to the community), with the power to prevent the use of the term "draughtsman" by an incompetent man, and to introduce a better term such as "designer" to describe a man versed in the higher branches of draughtsmanship. Any such term should have a legal significance so that a man having the right to use it would be accepted in a court of law as being a competent person, unless evidence to the contrary were produced. Improved status and remuneration would follow.

Such is the position attained by those brain-workers who have succeeded in convincing the general public that they are intellectual and valuable members of society, and they can all be grouped under the title "professional men." If the Association of Engineering and Shipbuilding Draughtsmen will work along such lines, while continuing to collect useful information as to the firms which appreciate good design and draughtsmanship and are prepared to pay for it, it will do lasting good to its members by raising their status, and to the engineering world in general by helping to produce better draughtsmen. In the much discussed "war after the war," if success is to be ensured, the best brains available will be required in the drawing office as well as in the consulting room. At the present time the attractions offered consist of hard work, considerable responsibility, and very few rewards; and if this situation is permitted to continue, few men of any ability will be induced to come forward to undertake such work, particularly if they realise at the outset that they will be treated intellectually and commercially as of small account.

In such a case the degradation of the draughtsman will only be a matter of time, and sooner or later a new class of technically-trained men will undertake under a new name, and under better conditions, all the higher class work now commonly done by draughtsmen, and the latter will find themselves permanently relegated to the position of "glorified tracers," while the newcomers reap the reward the draughtsmen should have made their own.

I am, Sir, yours faithfully,
A. J. Knight, B.Sc. (Lond.).

66, Elmfield-road, Balham, S.W.
November 19, 1917.

To the Editor of Engineering.

Sir,—I hope you will allow me further to trespass on your space to remark on the letter of "Senior A.S.E." (November 16 issue).

The position of drawing-office men may be put in few words. Draughtsmen occupy a strong vantage ground in that their number is small as compared with the total wage-earners in engineering and shipbuilding for whom they prepare the first technical essentials to work of the industries concerned—about 1 per cent. to 3 per cent. as measured in wage figures, I should say. No body of employers is, therefore, likely to forego their profits and hold up their establishments, with scores of workmen to each individual draughtsman, provided the requests made are reasonable and presented with a united front. As the present wages of draughtsmen are certainly not what they should be, with regard to responsibilities, training necessary and social position to maintain, there seems good prospect of successful advance by reasonable stages as long as we keep the advantages due to our unique position.

Consequently, working arrangements with the shop trade unions should be made by cordial co-operation of our association with such bodies when our interests demand it, just as we find the regular trade unions doing among themselves when (and only when) their particular interests are thereby served—not by direct binding amalgamations, nor, still less, by draughtsmen forsaking their strong position to join such amorphous organisations as the Amalgamated Society of Engineers, as your correspondent suggests.

Further than this, a very large proportion of the membership of the Association of Engineering and Shipbuilding Draughtsmen is made up of men without qualification for joining the Amalgamated Society of Engineers, such as electrical, structural and ship draughtsmen, and is it to be inferred that a special association for these alone is suggested?

Yours faithfully,
"Accelerando."

To the Editor of Engineering.

Sir,—Your correspondent, "Senior A.S.E.," has given embodiment to one of the strongest influences which in the past have prevented draughtsmen reaping the full reward of their education, skill, and technical knowledge, and which have tended towards the lowering of the dignity and status of the profession. I refer to the influence of self-depreciation.

His advice is tantamount to counselling authors to join the printers' trade union, or advising medical men to become members of an association of funeral undertakers. The suggestion comes rather late in the day, however, draughtsmen having awakened to the fact that combination, as draughtsmen, is essential to their well-being, and the astonishing growth and present strength of the A.E.S.D. are eloquent reply to such counsels of abnegation.

Your correspondent arouses either suspicion of his *bona fides* or wonder at his childish simplicity. If the former view be correct, may his doctrines perish with him; but if the latter, it will be necessary to point out to him and those who think with him, what is implied by their policy. In the first place, the profession of draughtsmen is made up of specialists in various branches of industry, roughly classed as, architectural, electrical, engineering, shipbuilding and structural. Your correspondent will readily observe that membership of the A.S.E. is debarred to most of these classes. They would thus have to join other unions, and, in addition (as in the case of shipbuilding), where there is a choice of several unions for some of these classes, this would result in the complete dismemberment of the profession, the loss of common action, the loss of professional *esprit-de-corps*, and the entire loss of identity.

In the second place, the spirit exhibited by "our workmates in the shops" towards draughtsmen generally, coupled with their comparatively small membership of the A.S.E., or other such union, would not tend towards very enthusiastic prosecution of their claims, and especially so, in view of the present very unsatisfactory position of draughtsmen, and the great amount of work to be done on their behalf.

Again, the inevitable result of your correspondent's policy would be the payment of the engineer's standard wages, to draughtsmen and the placing them on the level, in all respects, of the working engineer. It is extremely unlikely that the trade unions would seek the aggrandisement of those whom they already consider a too much favoured class!

It is the pathetic appeal of "Senior A.S.E." which arouses our suspicions of his *bona fides*. "The union which has helped us in the past." The good is oft interred with men's bones. So must it be in this case, for most of us had never heard of it. We are, if such be fact, very grateful, but all this is beside the mark. Union is strength, and in founding the A.E.S.D., we have taken cognizance of the truth that unity of ideals, of purpose and of identity is absolutely necessary to ensure harmony, enthusiasm and effort in the great task of establishing our profession in its true position, an aim which is altogether outside the province of the A.S.E. or any other such body.

Let me, in conclusion, counsel "Senior A.S.E." to be loyal, first, to his craft and to his fellows. Let the A.S.E. do their work. We shall do ours.

I am,
"Loyalty."

To the Editor of Engineering.

Sir,—The draughtsmen in general are under a deep debt of gratitude to you for allowing them the use of your valuable journal to discuss their status at the present moment. Being a draughtsman myself and a member of the Association of Engineering and Shipbuilding Draughtsmen, I have carefully read all the correspondence on the subjects at issue and have been pleased at the tone of the letters of all the writers, although naturally they could not see eye to eye in every detail.

One thing I make out is absolutely certain, and that is that unless the draughtsmen have a strong association, both numerically and financially, they will be ignored to a large extent not only by Government departments but also by some masters. There will, of course, always be a percentage of draughtsmen who will be able to receive due consideration of their merits, partly because of their outstanding abilities, but in a greater measure due to the employer with whom they are engaged, if he be a fair-minded gentleman and not a veritable slave-driver who is out to grind the last ounce of sap out of his employees at a minimum salary.

Some of us are very fortunate in having good principals to work under, and in the event of the draughtsmen's association making a combined effort to improve the lot of the poorly paid hands, these good firms would not suffer in the least. In point of fact, I believe they would inwardly wish success to such a move, as it would put all firms on a more equitable footing as regards competitive work in the markets.

There is only one other point I wish to refer to, and that is the remarks of "An Old Draughtsman" in your issue of the 9th inst. The second paragraph of his letter reads thus: "I have often noticed that a draughtsman with an outside hobby—music, art or literature, for example—goes ahead better than his colleague whose profession is his sole hobby, and this I think is because the former acquires broader views of life." These remarks I consider very true, and I, too, have noted the same during my experience. Not only are they correct, but the possession of the ability to play, sing or recite, helps office chums to attain a measure of intimacy with each other which would otherwise be impossible, the old proverb being true in this sphere also—"Birds of a feather flock together." I could extend further on this point to prove my assertion, but refrain in case of being misinterpreted.

Apologising for trespassing so much on your valuable space,

I am, yours truly,
"Work and Play."

WORM GEARING.

To the Editor of Engineering.

Sir,—In reply to the letter of Mr. Bostock on Worm Gearing, I would mention that the subject of spur gearing need not be introduced into the argument, and that in an argument it is hardly fair to say what the other man "would" or "ought" to say about something else without his consent.

He admits that my definition of "velocity of rubbing" is correct, and yet he fails to appreciate the results of accepting such a definition. I would remind him that a definition is an exact statement by which the meaning of some word or words is known or determined. In the case in point, since velocity of motion of the point of contact does not enter into the definition it cannot be "necessary," as he says it is, to take it into account in computing the "velocity of rubbing." The matter is only one of a very simple nature. I would like to ask Mr. Bostock how he accounts for the following fact:—

If we have two surfaces, A B and C D, in contact as shown in the diagram, and A B moves $\frac{1}{4}$ in. to A^1B^1

(5300)

while C D remains fixed, then there must have been $\frac{1}{4}$ in. of rubbing action, and whether the point of contact has moved either backwards or forwards due to an added rolling is quite immaterial and need not be taken into account in computing the amount of rubbing which has taken place. In his case he claims that the movement of the point of contact annihilates two-thirds of the rubbing.

Yours faithfully,
Walter C. M. Pettingill, B.Sc.(Lond.).

Rochester, November 18, 1917.

To the Editor of Engineering.

Sir,—The Interesting paper on "Worm Gearing" contained in your issues of the 2nd and 9th inst. correctly states the ratio of the useful work done to the power expended, viz.:—

$$\eta = \frac{\tan\theta}{\tan(\theta+\mu)} = \text{say } \frac{w}{v}.$$

As is well known this expression is a maximum when

$$\frac{v \,.\, d\,w - w \,.\, d\,v}{v^2} = 0,$$

i.e., $$v \,.\, d\,w = w \,.\, d\,v,$$

or $$\frac{d \,.\, \tan\theta}{\tan\theta} = \frac{d \,.\, \tan(\theta+\mu)}{\tan(\theta+\mu)},$$

i.e., $$\sin 2\,\theta = \sin 2\,(\theta+\mu)$$

So that the efficiency is a maximum when

$$2\,\theta = 90 \text{ deg.} - \mu \text{ and } \theta = 45 \text{ deg.} - \frac{\mu}{2}.$$

It can readily be seen that $\frac{\tan\theta}{\tan(\theta+\mu)} = 100$ per cent. efficiency when μ, the angle of repose, is 0 deg. for any value whatsoever of θ. Also the maximum value of the expression, viz.:—

$$\frac{\tan\left(45 \text{ deg.} - \frac{\mu}{2}\right)}{\tan\left(45 \text{ deg.} + \frac{\mu}{2}\right)} = 100 \text{ per cent. when } \frac{\mu}{2} = 0 \text{ deg.}$$

Is it possible, however, to accept the author's claim of 96 per cent. to 98 per cent. efficiency for worm gearing? Even with plain horizontal rubbing surfaces on ball bearings, can the angle of repose be eliminated to the extent implied by such results for worm gearing, however perfect the design and manufacture?

It would appear that if such results can be substantiated then we need no longer despair of perpetual motion.

Yours truly,
John Dow.

Junior Reform Club, Liverpool,
November 16, 1917.

British Industries Fair, 1918.—As certain trade associations connected with trades eligible to participate in the British Industries Fair 1918, have until recently been unable to hold meetings to discuss concerted participation, and in order to suit the convenience of a section of the trade Press, the Board of Trade have decided to extend the final date for the receipt of applications for space until November 30. The difficulties of organisation due to the war make it of the highest importance, however, that all applications should be sent to the Director, British Industries Fair, 10, Basinghall-street London, E.C. 2, at the earliest possible moment. The applications for space so far received from manufacturers point to the coming fair being greatly increased both in size and importance.

Conference of Motor Transport Interests.—Delegates from all parts of the country were present at the last meeting of the Joint Committee of Mechanical Road Transport Associations held in London recently. The Joint Committee, which was established in 1912, is fully representative of all interests dealing with the transport of goods and agricultural produce by mechanically-propelled vehicles. The committee decided to institute effective opposition to the resolution passed by some of the County Councils having for its object the restriction of heavy motor traffic and to approach the Chief Commissioner of Police of the Metropolis with a view to the committee being officially represented at the forthcoming Conference between the Police and the Local Authorities to consider the establishment of roadside fuel supply stations. The committee is also arranging to issue a list of watering stations throughout the country where steam vehicles will be enabled to draw supplies of water. The Hon. Secretary to the Joint Committee, Mr. Bristow, F.C.I.S., 83, Pall Mall, S.W. 1, will be pleased to forward to anyone interested a copy when the list is ready.

MICHELL'S AUTOMATIC LUBRICATING GEAR.

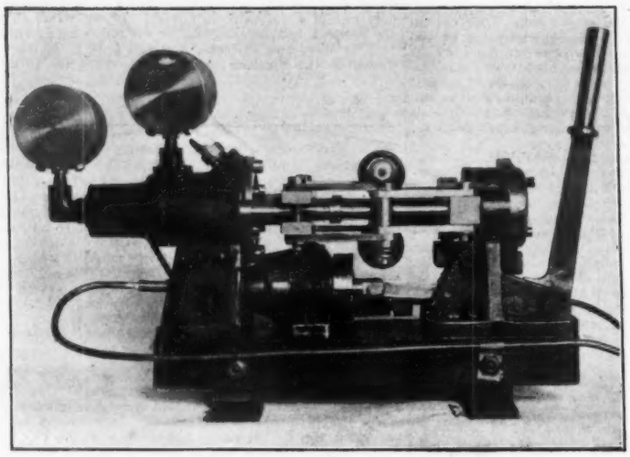


Fig. 1.

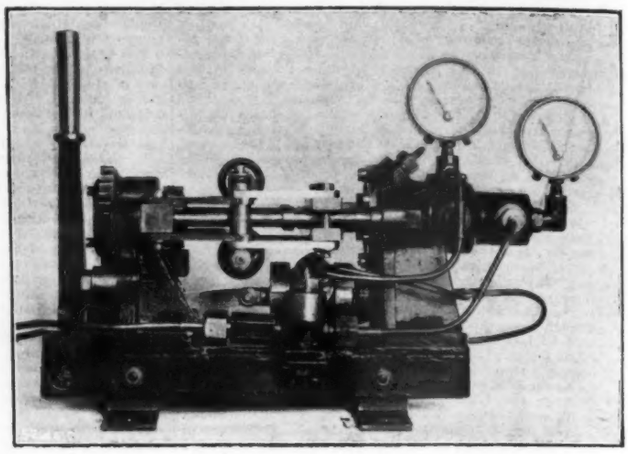


Fig. 2.

The improvements in the methods of constructing and lubricating bearings, which have been developed during recent years as a consequence of the investigations of Beauchamp Tower, Osborne Reynolds, and others, have made it possible to realise almost ideal conditions in the operation of bearings, provided that the loads and speeds are known and constant. It is now possible, with proper design, to provide machines with either journal or thrust bearings which, as long as they are run under constant conditions, are self-lubricating, and as a consequence practically immune from wear or deterioration, and which will operate with a coefficient of friction of $\frac{1}{1000}$ or less. The mechanical losses of any machine arising from bearing friction can consequently in most cases be made practically negligible. But when heavily loaded machines have to be frequently stopped and restarted, complications arise, and the situation is not nearly so favourable. Failure of automatic lubrication at the moments of starting and stopping involves not only greatly increased friction at those times, but wear of the surfaces, which ultimately destroys the self-lubricating property. It is not uncommon with various types of heavy electrical machines for special means to be provided to overcome the bearing resistances at starting, especially when the electrical characteristics are such that the starting torque is insufficient to overcome the friction of non-lubricated bearing surfaces. In some cases force pumps have been provided for the purpose of supplying lubricant under pressure to the bearing surfaces during starting, and also during stopping, with the double object of starting the machine without excessive armature current and of reducing the damage which is caused to the bearings by running them even for short periods with imperfect lubrication. The complications added to the plant by the installation of oil-pumps, with their driving motors and starting apparatus, and the troubles incidental to the pumping of oil at the high pressures necessary, have, however, prevented the general adoption of this solution. In other cases the difficulty has been met by the use of ball bearings or roller bearings, up to the limits of speed and pressure for which these types of bearings are considered to be admissible.

We give below a description of a new type of apparatus which has been developed by Mr. Michell, the inventor of the Michell thrust and journal bearings, for the purpose of lubricating bearings during starting and stopping by means of an automatic device which does not require the application of any auxiliary driving power. The apparatus, which is simply a specialised accumulator, requires no pumps for its operation, but is actuated entirely by the flow of oil, which is maintained under pressure between the working surfaces of the bearing during running at normal speed, the maintenance of such pressure being essential to the effective lubrication of the bearing, as is now well understood. To secure the full advantages of the device and its reliable operation, the bearing brasses or blocks are preferably pivoted on the system introduced by Mr. Michell. In the diagrams and photographs of the arrangement of the apparatus reproduced on this and the opposite page, the apparatus is shown as applied to a journal bearing. The general views of the gear represented in Figs. 1 to 4, annexed, will be best understood after a study of the diagrammatic elevations and sections, Figs. 5 to 7, page 549. As indicated in Fig. 7 the top brass of the bearing is pivoted on a hollow stud making oil-tight contact with the brass, through which a hole is drilled to its working face at, or near, the point where the oil pressure is a maximum. Assuming that the bearing is subject to a constant load of 500 lb. per square inch of the projected area of its brasses, oil is supplied during normal running of the machine by the automatic action of the pivoted brass through the pipe and valves above-mentioned, at a pressure of, say, 900 lb. per square nch. The outer end of the hollow stud is connected by the pressure pipe to the accumulator cylinder, which is constructed on the intensifier principle, shown to the right in Figs. 6 and 7, having a large and small chamber in tandem, and fitted with a stepped plunger turned to corresponding diameters. The pressure-pipe delivers oil from the bearing into both chambers of the accumulator, forcing the plunger outwards and extending the loading springs, which are arranged to apply a practically constant load on the plunger of the accumulator by means of the toggle motion clearly shown in Fig. 6 and in the general views Figs. 1, 2 and 3. When the outward motion of the plunger is completed, it is held in that position, by means of the detent nut (Fig. 7) and a pawl (Fig. 5) engaging with the nut, whether the bearing continues to run or not until the starting handle is shifted to the starting position. The accumulator is fully charged in a few minutes of normal running, and the plunger remains at the outer end of its stroke during the remainder of the time that the motor is running, and, as already mentioned, after it stops. As the detent nut retains the plunger against the load imposed by the loading springs, the latter impose no pressure on the oil once the pawl is engaged, and little or no leakage takes place from the accumulator while the motor is stopped. At stopping, the starting handle is moved over simultaneously with the motor switch, a motion which simply returns this handle to the starting position without affecting the position of the accumulator plunger.

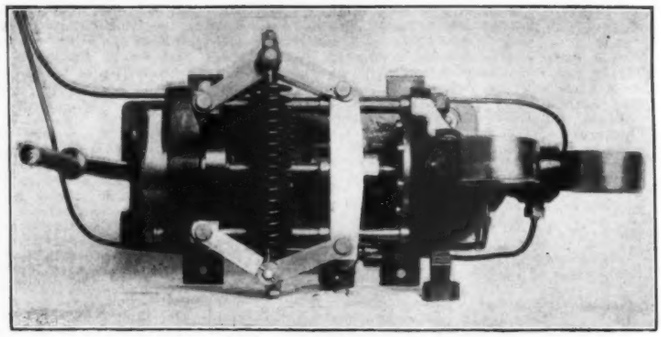


Fig. 3.

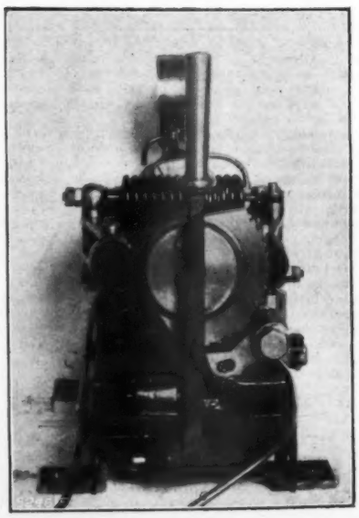
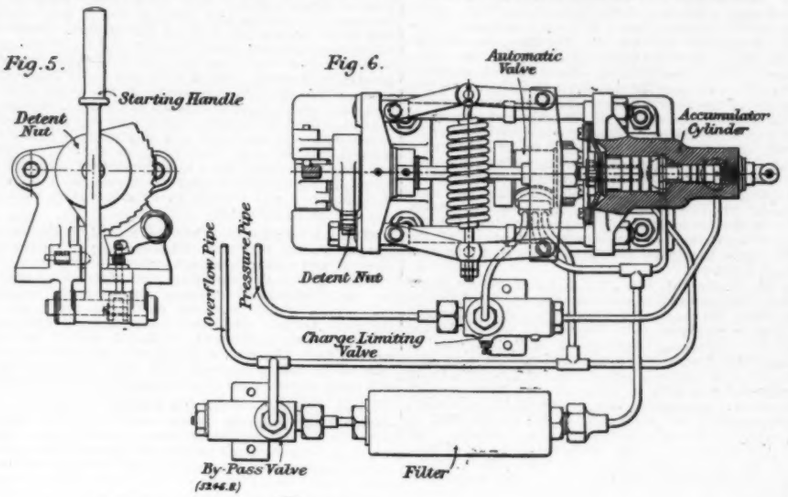
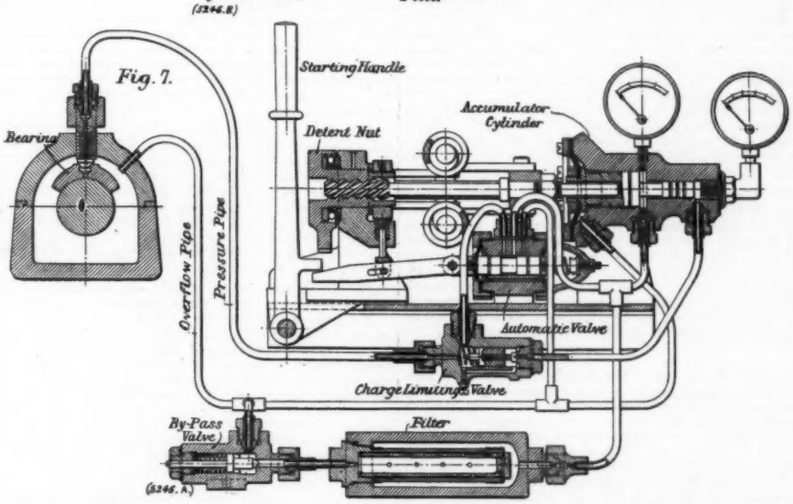


Fig. 4.

To start the machine the starting handle is shifted simultaneously with the closing of the motor switch. In this forward motion of the handle the pawl is lifted out of engagement with the detent nut, allowing the nut to rotate, and the plunger to be driven back under the tension of the loading springs. At the same time the large chamber of the accumulator is allowed, by a changed position of the automatic valve shown in section in Fig. 7, to discharge freely through the overflow pipe into the well of the bearing, and thus the whole tension of the loading springs is applied to intensify the oil pressure in the small chamber of the accumulator up to, say, 2,500 lb. per square inch, and oil at this pressure is discharged back through the pressure pipe to the bearing. By this means a film of oil is forced between the bearing surfaces, lifting the rotor to the extent of, say, $\frac{1}{1000}$ in., and allowing

MICHELL'S AUTOMATIC LUBRICATING GEAR.





it to start without solid friction on the bearing surfaces with a comparatively very small starting current. Actual test has shown that, whereas the coefficient of friction of the bearings on their brasses amounts to 0.18 under the usual conditions of starting, even if the starting is effected almost immediately after stopping, so that the surfaces retain an appreciable amount of oil, the effective coefficient drops to less than 0.01 when the accumulator is used for starting as above described. Thus, taking the case of a rotor weighing 5 tons, with journals 4-in. in diameter, the starting couple necessary with the usual conditions of starting would be 336 ft.-lb., whereas by the use of the accumulator the couple is reduced to less than 20 ft.-lb. It is to be noticed that the higher coefficient of friction still exists when, according to a common practice, the bearings are flooded with oil at low pressure by a circulating pump immediately before starting. The only advantage of this flooding is that the bearings are enabled to form effective lubricating films more quickly than if the oil circulation did not begin until the motor got up speed. The quantity of oil required to be fed to the bearing from the accumulator at starting varies according to the size of the bearing and to the rate at which the motor acquires speed. It is, however, surprisingly small, at least until the surface speed of the bearing reaches some feet per second, by which time automatic lubrication will again be effective. A 4-in. bearing starting slowly requires oil to be fed to it at starting at about the rate of 1 cub. in. per minute, and such a bearing can in some cases be started with less than $\frac{1}{10}$ cub. in. of oil. For other sizes the quantity will be proportional, other things being equal, to the square of the diameter.

On the other hand the rate of charging of the accumulator from a 4-in. bearing, running at 1,000 r.p.m., is approximately 3 cub. in. per minute, and for other bearings and speeds the rate of charging will be approximately proportional to the cube of the diameter of the bearing and to the speed of rotation. It will be seen that a comparatively very short part of the normal running time of the machine suffices for charging the accumulator sufficiently for the restarting action. During the greater portion of the running time of the machine, therefore, the accumulator stands fully charged. This fact is made use of in the apparatus illustrated to effect the continuous filtration of the oil, a high-pressure filter and filter valve being arranged in parallel with the accumulator cylinder as indicated in Figs. 6 and 7. A continuous flow of oil is thus maintained through the pressure pipe and filter and back through the overflow pipe to the bearing. The filter is automatically switched in and out of the circuit by means of the filter valve attached to it.

The filter itself requires only to be of comparatively small size on account of the intense pressure, usually exceeding 1,000 lb. per square inch, which is available for driving the oil through it. In addition to the filter a cooling coil may be used on the by-pass of the accumulator if desired, and here also the high pressure available enables such coils to be made of small size without imparing their effectiveness. For the same reason the connecting pipes may be of quite small diameter, without risk of their becoming obstructed, and the apparatus is exempt from one of the chief troubles attaching to the use of oil-circulating pumps, namely, that of the pipes, especially on the suction side of the pump, becoming clogged, even when of considerable size.

The above description assumes that only one bearing is connected to the apparatus. In practice, however, one accumulator may supply all the bearings of the unit to which it is applied, and in many cases one accumulator can be made to serve several units. In such cases it is desirable to fit an additional attachment which is known as a charge-limiting valve, and is shown properly connected up in Fig. 7. This valve serves the purpose of limiting to a definite quantity the flow delivered from the accumulator to the bearing to which the valve is fitted, and thus in the case where a number of bearings are supplied from one accumulator it prevents any particular bearing which may be loosely fitted, or which may get up speed more rapidly than the other bearings, from monopolising too much of the capacity of the accumulator to the disadvantage of the others. The charge-limiting valve, fitted in combination with an accumulator cylinder of large size, also enables the latter to serve without recharging for starting a machine several times. How this is done will appear from the following description. The device consists of a cylindrical tube enclosing a closely fitted plunger, which also serves as a valve closing the outlet. Normally the plunger is kept off the valve seat by a coiled spring (see Fig. 7), and in that case continuous flow can take place past the plunger through the by-pass pipe. When a charge of oil is delivered from the accumulator to the bearing at starting, it is admitted in the first instance behind the plunger of the charge-limiting valve, the latter delivering to the bearing a quantity of oil from the front end of the cylinder equal to the quantity which enters behind the plunger. But when the plunger reaches the end of its travel and closes the outlet, further flow is prevented and the action stopped. The stroke of the plunger is adjusted so that the quantity of oil supplied is sufficient to enable the particular bearing supplied to start under load, and the accumulator is only discharged to this extent, while still retaining sufficient oil to enable several fresh starts to be made. In order that this may be done, the plunger of the charge valve must have time to move back under the operation of its spring, displacing oil from behind it through the by-pass to the front end of the cylinder, this action taking place in about half a minute. Everything is then in the original position and ready for a fresh start according to the same sequence of operations.

The whole apparatus is of such small size that it may be quite conveniently attached to the machine which it serves, or it may be placed on an adjacent wall bracket, occupying no floor space. It may be placed at either a higher or lower level than the machine bearings as may be most convenient, since the flow of the oil does not depend on gravitation or suction.

The apparatus shown by the photographs was made in Australia, where the tests with it were also carried out by Mr. Michell. His British representative is Mr. H. T. Nowbigin, A.M.I.C.E., 3, Nicholas Buildings, Newcastle-on-Tyne, who has arranged for its manufacture here by Vickers Limited.

Decimal Coinage.—At a joint meeting of the Institute of Bankers, the Association of Chambers of Commerce and the Decimal Association, unanimous agreement was secured as to the retention of the £ sterling as the monetary unit and its division into 1,000 parts or mils, according to the latter association, who add that this measure enables all the existing gold and silver coins down to and including the 6*d.* piece to be retained without any alteration in their respective values. For example, the 6*d.* is represented exactly by 25 mils. In regard to the coins of lower denomination, it was unanimously agreed that they shall consist of 1 mil, 2 mil, 3 mil, 4 m*il*, 5 mil and 10 mil pieces, of which the two latter would be of nickel. The Decimal Association further states that the enlarged range of the coins of lower value, in addition to providing coins substantially equal in value to the existing ½*d.* and 1*d.*, will provide coins of intermediate value between the present ½*d.* and 1*d.*, and thus overcome a defect in our present coinage which has resulted in prices in millions of small transactions in daily life being unduly increased because of the absence of suitable intermediate coins.

How Long would it Take a Stone to Fall to the Centre of the Earth?—This problem exercised the minds of several geometers of the past century, and they arrived at widely-differing results. Mersenne stated that, if a shaft could be driven down to the centre of the earth, it would take a stone 6 hours to fall from the earth's surface to the centre, whilst Gassendi only wanted 20 minutes for the same fall. According to the recent calculations of Maurice Sauger (*Comptes Rendus*, vol. 164, pages 954–957), Gassendi was right. As the stone approaches the centre, it is drawn downward by the core of the earth, and upward by the shell which it has already penetrated. The rate at which the density of the earth varies or increases as we penetrate to greater depth is unknown. Assuming an average density of 5.53, the time of fall should be 1,234 seconds, Sauger finds; that would be 20 minutes 34 seconds. If the density S should vary according to the relation $\rho = 10 (1 - 0.76\, r^2/R^2)$, where r is the distance of the spot from the centre of the earth, and R its distance from the surface, the time of the fall would come out 19 minutes 15 seconds. The two values differ only by 79 seconds, a little more than a minute. Sauger's formula is based upon considerations of the moment of inertia of the earth, as calculated from the precession of the equinoxes, which agree with observations on the density of the earth conducted in mine shafts. If the shaft were driven right through the earth, the stone would appear at the antipodes after 38 minutes and 30 seconds, and return to its starting point, at which it would make its re-appearance at the end of 1 hour 17 minutes.

THE HARDINGE BRIDGE.

*The Hardinge Bridge over the Lower Ganges at Sara.**

By Sir Robert Richard Gales, F.C.H., M.Inst.C.E.

The Hardinge Bridge connects the standard 5-ft. 6-in. gauge system of the Eastern Bengal Railway south of the Ganges with the metre-gauge system north of the river. It comprises 15 girder spans of 345 ft. 1½ in., with three land spans of 75 ft. at each end. The paper deals first with the conditions of the site, in the recent delta of a great river. A short description of the delta is given, and attention is drawn to the desirability of the construction of certain railway connections for traffic reasons, and for the purpose of creating a tendency to further stabilisation of the course of the river.

The local choice of site and the design and construction of the training-works considered necessary to render permanent the channel of the river in the immediate vicinity of the bridge are then described, and the particulars given show that the training works alone constitute a work of great size. The considerations on which the main dimensions of the bridge have been based are detailed, and attention is drawn to the very large flood discharge, which appears to challenge comparison with that of any river yet bridged.

The magnitude of the work, the high and increasing cost of Indian labour, and the importance of rapid completion, indicated the desirability of making greater use of modern plant and special methods of construction than had hitherto been considered economical in India; and the paper describes the methods of construction adopted, which briefly, were the laying down of electric power plant and the use of electric power throughout the bridge, the use of cement concrete blocks in the steening of the well foundations, thereby ensuring great weight in the wells and rapidity in building and sinking, and the employment of a temporary service girder of large span for girder erection in the water spans, thereby ensuring greater certainty and rapidity of construction and a longer working season than was possible with timber staging under the conditions obtaining.

The rate of construction and details of cost are stated, and, it is believed, show that the bridge was constructed both rapidly and economically. The paper also gives a description of the temporary service works and of the medical and sanitary arrangements, which may be of use to engineers who have large works to carry out in similar conditions of isolation and climate.

Standardisation of Petrol Gauze.—Considerable trouble and delay has been experienced in obtaining a regular supply of petrol gauze, primarily due to the fact that aircraft contractors depended upon importation for the finer mesh required for this very important accessory of aeronautical engines, and it was found that a wide variety of mesh was called for by different manufacturers, although they required the mesh for similar purposes, and in some cases it was very difficult to justify distinction. For instance, the difference in the width of the aperture between 200-mesh gauze and 180-mesh gauze is only 1 ten-thousandth of an inch. There has been a tendency to call for meshes much finer than are justified by the conditions. This has resulted in the use of a gauze which is much more fragile than is necessary or desirable. To overcome this difficulty, the Air Board took the leading manufacturers of wire cloth into consultation, and the Royal Aircraft Factory experts made certain experiments, which have resulted in a standardised gauze being agreed upon. This will greatly facilitate manufacture, and will enable the material to be produced in Great Britain in adequate quantities to meet the demands from aircraft factories. The gauze will be known as "Air Board Standard Petrol Gauze," and all orders and inquiries should be sent to the Air Board Office, S.(H.A.)5, Room 609, Strand, W.C. 2.

Sewage and Its Precipitation.—"Sewage and its Precipitation; Further Experiments," was the subject of a paper read by Mr. Reginald Brown, M.Inst. C.E. M.I.Mech.E., F.S.I., F.R.San.I., before the Society of Engineers (Incorporated) on Monday, the 19th inst., in the premises of the Geological Society, Burlington House, Piccadilly, W. In 1916 the author read a paper on the same subject before the society and dealt with experiments with (1) ferric sulphate (solid), (2) ferric sulphate (solid) and lime, (3) sulphate of alumina and lime, and the experiments described in the present paper dealt with the results from the use of (1) lime; (2) ferric sulphate (liquid) and lime; and (3) sulphate of alumina and lime the latter being used in both series of tests so as, if possible, to form some basis of comparison and a connecting link between the two series. The author dealt with the importance of a knowledge of the varying quality of the sewage, especially due to trade wastes and the increase in the cost of various precipitants; he pointed out that a correct understanding of the varying character of a sewage was necessary, as a continuance of a particular discharge of trade waste might, unless stopped or specially dealt with, have a very serious effect upon the efficiency of the whole plant at a sewage disposal works. The first series of experiments showed the superiority of the use of sulphate of alumina and lime, and the second series carried the same conviction. The author, however, emphasised the importance of the results on a particular class of sewage and laid no claim to the use of any particular precipitant as a panacea for the treatment of all classes of sewage where chemical treatment might be necessary.

* Abstract of paper read before the Institution of Civil Engineers, November 20, 1917.

THE ROYAL METEOROLOGICAL SOCIETY.

The first monthly meeting of this society for the present session was held on Wednesday, the 21st inst., at the Society's Rooms, 70, Victoria-street, Westminster, Major H. G. Lyons, D.Sc., F.R.S., President, in the chair. A paper, by Dr. G. C. Simpson, F.R.S., F.R.Met.Soc., Meteorologist, Government of India, entitled "*The Twelve-hourly Barometer Oscillation*" was read, a summary of which is as follows: (1) The existence of the twelve-hourly atmospheric vibrations, one parallel to the circles of latitude and the other parallel to the meridians, first suggested by A. Schmidt in 1890, and investigated by E. Alt in 1909, has been proved. (2) A mathematical expression for the amplitude and phase of each vibration containing the geographical position as the only variable has been obtained. (3) The interference of these two waves has been shown to account very completely for the observed variations in amplitude and phase of the twelve-hourly barometer oscillations, especially in high northern latitudes.

Mr. W. W. Bryant, B.A., F.R.Met.Soc., read a paper entitled "*Abnormal Temperature, with Special Reference to the Daily Maximum Air Temperature at Greenwich.*" The author proposes that for certain meteorological elements a value shall be defined as "abnormal" if the departure from a well established normal is at least twice the mean residual, both normal and residual being determined by smoothing values from a long series of observations. He applies this method to the maximum air temperatures at Greenwich for the period 1841 to 1916, using the first sixty-five years as a standard. The limit thus calculated varies at different times of year from 8 deg. F. to 12.5 deg. F., so that a fixed limit of 10 deg. would not be applicable. In the analysis it appears that one day in 10 is abnormal, the proportion being higher in the months from May to October, and much lower in December and January. Additional tables deal with spells or alternations of heat and cold, and generally with the distribution of abnormal days. The principle is also extended to monthly and annual values and the effect of a higher limit, three or four times the mean residual, is considered. The relatively hottest month in the period was 1846 June, and the coldest 1890 December, the hottest year 1868 and the coldest 1879.

Coal-Handling Plant at Durban.—In the article published in our issue of August 17 last in connection with the above-mentioned plant, we omitted to mention that the preliminary plans and general outline of the scheme as constructed were prepared by Mr. A. M. Tippett, M.Inst.C.E., engineer-in-chief of the South African Railways, and the construction of the plant at Erith was supervised by Mr. G. Thomson, a member of the engineering staff of the South African Railways.

Thermit Welding.—The Board of Trade have now given formal sanction to a new company, with works in London and Liverpool, and known as the British Barimar-Thermit Welding Company, Limited, to take up and exploit the Thermit welding process which, prior to the war, was exclusively in German hands. Thermit is specially applicable for tramway welding and for the repair of heavy castings and machine parts. The registered offices of the new company are at 10, Poland-street, London, W. 1. Messrs. Thermit, Limited of 675, Commercial-road, London, inform us that they are the owners of the Alumino-Thermic process patents, and are not connected with the new company above referred to, who merely hold a licence to work certain of the patents belonging to them. Thermit, Limited, were originally established in 1904 and about eighteen months ago the whole of the shares were sold to the Birmingham Metal and Munitions Company, Limited, Birmingham. They continue their manufacture of various Thermit compounds, and are at present especially engaged upon the manufacture of certain metals and alloys in connection with munitions of war.

Technical Committee of the Motor Industries.—The fourth meeting of the Technical Committee of the Motor Industries was held at the offices of the Institution of Automobile Engineers on November 6, 1917, at 2.30 p.m. Questions of standardisation occupied a large part of the proceedings, and recommendations were submitted for the consideration of the Engineering Standards Committee in regard to bolt type detachable wheels for pneumatic tyres, tyre sizes, loads and inflation pressures, road springs and chassis dimensions for carriage work. Three sub-committees were appointed to consider and report upon: (1) Fuel for internal-combustion engines; (2) the formation of an education committee; (3) the proposed laboratory for internal-combustion engine research. These are solely internal committees, and are not put forward in any way with a view to overlapping the work which is being carried out by other committees in the same direction. The standardisation of automobile parts has now been under consideration by the Engineering Standards Committee for some considerable time, and the result of the work of the numerous sub-committees is beginning to bear fruit. The following reports have already been issued by that body, and may be obtained from the Engineering Standards Committee, 28, Victoria-street, S.W.1: No. 71, Report on British Standard Dimensions of Wheel Rims and Tyre Bands for Solid Rubber Tyres; No. 80, Report on British Standard Dimensions of Magnetos; No. 45, Report on British Standard Dimensions for Sparking Plugs. The reports are now issued at the standard price of 1*s.* per report.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—The activity in the local steel trade increases rather than diminishes. Pressure for delivery is intense, and nothing which may in any way speed-up matters is being left undone. From the Allied Governments come constant and heavy demands for large quantities of material required for war purposes, practically the only class of work now being undertaken at any of the steel-making establishments in the West of Scotland, where every rolling mill is under Government control. The war material required by our own Government comprises shell bars and shipbuilding plates and sections. It is more than probable that a complete revision of prices will have to be considered very shortly, owing mainly to the increased cost of coke, and, following that, pig-iron, and there is every expectation that the rise will be considerable.

Malleable Iron Trade.—Ceaseless activity is the leading feature of the malleable iron industry; orders are plentiful and makers are hard pressed to keep pace with the demands made upon them, most of which, of course, are on Government account, for work of national importance. Small sizes in particular are much in request. As was confidently expected, the price of "Crown" bars has already stiffened, and at 16*l.* 10*s.* per ton f.o.b. Glasgow, a record rate has been reached. The recent heavy demand made upon ordinary ingot and shell discard steel is now causing some scarcity.

Scotch Pig-Iron.—With the demand for pig-iron for steel-making purposes being ever on the increase, hematite is moving away freely, while every other brand and quality is just as speedily taken off the market. In the market a firm tone rules, and where prices have been "free" rapid advances have already been noted, the increase in some instances having amounted to fully 10*s.* per ton. This has been rendered absolutely necessary owing to the increased on-cost charges. So far as the controlled prices are concerned no definite pronouncement has yet been made, but changes are bound to come and that speedily. Little export business is being put through.

Shipyard Extension at Bowling.—Messrs. Scott and Sons, whose shipbuilding yard and repairing works are situated at the western terminus of the Forth and Clyde Canal at Bowling, have just acquired a piece of ground east of their present premises, upon which they purpose constructing, among other extensions, a tidal basin and a graving dock for medium-sized vessels. When completed, these extensions will greatly facilitate the work of ship-building and ship-repairing as at present carried on by the firm.

Edinburgh and Scrap Metal.—Edinburgh has taken up the scrap metal question in most enthusiastic fashion, and a day or two ago the Lord Provost, Sir J. Lorne, Macleod, presided at a conference convened at the request of the Government department which has been brought into existence for the purpose of dealing with the collection of the scrap metal required for the manufacture of munitions. It was pointed out to the very representative meeting that scrap metal was urgently needed at every iron and steel works in the country, and that Scotland had been asked to provide 50,000 tons. Suggestions were made as to the best means of collecting small quantities of metal.

Mineral Production of Victoria.—The Secretary for Mines of Victoria, in the Commonwealth of Australia, in his annual report for the year 1916, gives the following yields of various metals and minerals during the year: Gold, 276,188 oz. gross, or 256,643 oz. fine; black coal, 417,183 tons; brown coal, 2,915 tons; antimony ore, 12,382 tons, yielding 3,259 tons concentrates; tin ore, 122 tons; manganese, 85 tons; gypsum, 1,853 tons; wolfram, 314 tons; magnesite, 100 tons; kaolin, 810 tons.

"The South African Journal of Industries."—We have received the first number of this new publication, for September, which is issued by authority of the Hon. F. S. Malan, Minister of Mines and Industries, Pretoria. It is published on, or about, the 15th of each month, at the price of 6*d.* per copy. It is to serve as a direct vehicle by means of which the public will be regularly and effectively acquainted with the results of the work done by the Department of Industries, a need which has been largely accentuated since the appointment of the Scientific and Technical Committee. The journal for September covers over 70 pages dealing with the mining, industrial, agricultural and other resources of South Africa, and contains much interesting information.

Russian Railways and Waterways.—In a recent paper read before the Société des Ingénieurs Civils de France, Mr. Gouvy stated that the total Russian railway system had, in 1913, a length of 95,900 versts, of which 83,000 were in Russia in Europe. This gave 1.2 km. for 100 sq. km., the corresponding figures being 8.9 in France, 10.6 in Germany and 3.9 in the United States. A vast programme made up in 1916 provided for the laying down of 6,000 versts per year during the first five years following the war. The necessary metal for new lines, for strengthening existing lines and for maintaining the fixed and rolling-stock of the whole system has been estimated at 638,000 tons annually. The Russian works would be able to supply this. The insufficiency of the railways is compensated for partly by the Russian waterways, which have a length of 82,000 versts in European Russia. (1 verst = 0.663 mile.)

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Whilst the call for fuels of all grades is more insistent than ever, there is little in the general position to call for special comment. As a matter of fact, the control and regulation of the coal trade just now is so extensive that few opportunities arise for events of outstanding character. Fewer agents are attending the local Coal Exchange, and the business transacted there is steadily declining. Collieries attribute this to the need for them to conserve almost the bulk of their output for contract and Government purposes. Inland consumption keeps on the increase, particularly the best steams used by works, railways, blast furnaces, &c., whilst the timekeeping at the pits is stated to be anything but good, and in some cases absenteeism amounts to 20 per cent. per day. The export trade is not large, though France and Italy are receiving fairly substantial tonnage. Gas sorts are passing for inland works on a moderate scale, but the companies are pressing for ample deliveries. Slacks are again strong, and there is practically nothing available for open market business. Quotations: best branch handpicked, 23*s.* to 24*s.*; Barnsley best silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* 6*d.* to 15*s.*; seconds, 13*s.* to 13*s.* 6*d.*; and smalls, 9*s.* to 10*s.* per ton at the pit.

Iron and Steel.—The tonnage of steel which is now being aimed at as the weekly output—the minimum—is stated to be so good as to give the utmost satisfaction to the authorities, and supplies are being delivered for ordinary war purposes in far superior quantities than was the case a few months ago. There has been further dilution of labour, and, less having been heard of the comb-out, workers have become more settled with the result that output has benefitted considerably. The acid steel production is one of the brightest features of the local situation, but the demand is so great that nothing can be set aside for surpluses to meet prospective emergencies. As a matter of fact, the whole of the steel placed on the market finds a ready inquiry, especially in some of the special brands. Aeroplane work comes into this last category. More electric furnaces are being used, but the specifications are truly on a mammoth scale. Marine work does not lessen, and works have their hands full. Fortunately makers are able to get satisfactory supplies of base material. More of the special sorts could be used with advantage. Nothing has yet been heard of the much-discussed increase in the tariff for common irons. The most that can be gathered in usually well-informed circles is that some action is inevitable and cannot now be long delayed. Business men are looking to numerous changes in iron and steel prices, but present buying and selling, having been made conditional upon any change being introduced in contracts, is not affected. Agricultural engineers report that they have many orders on hand for the more complicated forms of machinery. They do not expect to repeat last year's successful trade in the implements for allotments and holdings, but such things as plough plates, machinery parts, whippletrees, discs, harrows, and cultivators are in urgent demand. File orders for all kinds of military and munition work are coming to hand. Cutlery manufacturers are reluctantly compelled to reduce their output for home trade, which is really booming. The raw material available will not allow them to cater for all the home and export business, and the Government urge concentration on the latter. Plate and silver firms are in much the same position.

The Glass Trade.—The Council of Sheffield University, in its annual report issued yesterday, states the work of the Glass Department continues to increase, both in the direction of instruction and research work. The buildings which were reported last year as being in course of erection are now completed, and an additional storey also added, and work has begun in the new premises, which form a model factory with the complete equipment for dealing with the scientific manufacture of glass on a commercial scale. A new departure is the opening of a lamp working school for training and research, and this section of the glass industry is the first of its kind to be established. With this venture two associations, the British Laboratory Ware Association and the British Chemical Ware Manufacturers' Association, are identified and are contributing towards its financial support. In addition to researches published, and research work for the Ministry of Munitions, a very large number of tests have been made for glass manufacturers in all parts of the United Kingdom. The Association of Glass Bottle Manufacturers of Great Britain and Ireland have contributed a capital sum of 860*l.*, and promised an annual contribution of 250*l.*

"THE WORK AND TRAINING OF THE ROYAL FLYING CORPS."—A publication having the above title is issued at the price of 2*s.* 6*d.* net, by authority of the Royal Flying Corps, at the offices of *The Illustrated London News*, 172, Strand, W.C.2. It opens with a brief review by Lord Hugh Cecil of the Corps in all the branches of its activities; then follow a number of admirable reproductions from photographs showing the men in training in the various specialities of the service: aeroplane construction and operation, gunnery, telegraphy, photography, and so forth, and illustrating also actual work carried out by flying machines. The publication is a most interesting record of this, "the greatest of the novelties of the war," to give it the application used by Lord Hugh Cecil.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Few new features are noticeable in the Cleveland pig-iron trade. Discussion is still heard concerning the question of advancing fixed maximum quotations so as to cover increased cost of production, but the opinion is becoming more and more pronounced that instead of rectifying the position by such a step the manufacturers are likely to be subsidised, the general view taken being that advance would disturb all other branches. It is pleasing to learn that distribution is being somewhat facilitated by a rather better service of trucks. As is usual about this period of the month, home business is quiet. There is a little more doing on export account. For home consumption No. 3 Cleveland pig-iron is 92*s.* 6*d.*, and that price also rules for No. 4 foundry and for No. 4 forge, whilst No. 1 is 96*s.* 6*d.*; and for shipment to the Allies, No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

Hematite Iron.—As regards East Coast hematite iron, producers experience some difficulty in satisfying home needs, the demand being very intense. Little iron is available for export. It is, however, gratifying to be assured that the stringent situation now promises to be relieved at an early date by a substantial increase in the make of basic iron, preparation for which is well forward. Nos. 1, 2, and 3 are 122*s.* 6*d.* for home use, and 141*s.* for export to the Allies. The position as regards advance in quotations or subsidies to producers is similar to that ruling in Cleveland pig-iron.

Foreign Ore.—Supplies of foreign ore are reported coming forward fairly well, the organised efforts to facilitate discharge of cargoes expediting distribution.

Coke.—With the heavy demand for coke for local consumption met by plentiful supply, the market is active. Medium blast-furnace qualities are 33*s.* at the ovens, and low phosphorus sorts 35*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Under heavy pressure for delivery of Government and shipyard work, manufacturers of finished iron and steel are kept so busily employed that they find it almost impossible to entertain ordinary commercial business. The question of the all-round readjustment of quotations continues to be discussed, but it is very difficult to form an opinion as to what action will be taken. Up to the present, to home customers, recognised market quotations stand:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 19*l.* 10*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 15*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Market.—The market has been very quiet in the transaction of new business. The price of coke (furnace and foundry) has been increased by 7*s.* 6*d.* per ton for inland purposes, and an attempt is being made to obtain an increased price for Admiralty supplies. The export price has not yet been altered. The difficulties of collieries producing the more bituminous coals have been accentuated by reason of the narrowing down of the list of collieries from which bunkers are admissible for shipment on board vessels engaged in oversea traffic. The authorities have been influenced in their recent selections by the desire to supply steamers with coals which will give them the best possible speed, and for other obvious reasons. South Wales is the best coalfield for smokeless steam coals, and in view of the urgent necessity of protecting our ships as far as possible from the attacks of enemy submarines, the authorities cannot act too carefully in the selection of coals for use as bunkers; but the narrowing process has necessarily reacted unfavourably on collieries where coals have hitherto been used either wholly, or partly, in mixed parcels, for bunkering purposes, and will increase the number of stoppages in certain districts. The improved demand, however, for the better steam-coal qualities will tend to diminish the number of stoppages in the best steam coal area, and if Welsh displaces other coals used as bunkers, the position in South Wales, on the whole, will be improved.

Newport.—It is reported that the Controller of Coal Mines intends to make a further alteration in the quantities of South Wales coals allocated for transport to the south-western counties. Since the scheme was introduced a few months ago there has already been three previous departures from the details of the original proposals, and it is feared that if existing arrangements are disturbed they will lead to renewed disorganisation in traffic and aggravate the difficulties, particularly of Monmouthshire coals. Very little business has been passing other than that incidental to shipments on Government or Allied account, and tonnage supplies are scarce.

The Recent Miners' Wage Advance.—The Coal Controller has been interviewed in regard to the action of the Government in ordering a uniform increase of 2*s.* 6*d.* per ton in the price of all coal, other than that supplied to France and Italy, to meet the cost of the increase of 1*s.* 6*d.* per day in the wages of all colliery workers. The incidence of the increased prices falls very unequally on colliery owners, and a proposal is put forward that the Controller should adopt a certain method of procedure which would have the effect of removing the present inequalities. The suggestion made by South Wales coalowners is that the Controller of Mines should take the revenue from the extra 2*s.* 6*d.* per ton into his own hands and pay the extra 1*s.* 6*d.* per day to the workmen out of the fund. The suggestion has met with some opposition from Midland owners, but it is understood that it is to receive the consideration of the different coalowners' associations in the country, and the decisions of those associations are to be reported to another meeting of the Mining Association to be held shortly.

A Question of Brokerage.—In the letter from the Board of Trade, accompanying the Coal Controller's directions as to the sale of coal, issued on June 28 last, it was stated that, in the case of shipments to France and Italy, the then existing arrangements as regards the question of brokerage on freights should continue, but that in the case of shipments to other destinations outside the United Kingdom the amount of brokerage to be retained by the exporter shall not exceed 6*d.* per ton, the balance being payable to the collieries from which the coals were shipped. It appears that some of the South Wales colliery companies are claiming that everything over 6*d.* per ton should now be refunded to them in respect of coals shipped under contracts, and a controversy has arisen as to whether this claim is valid in view of the direction that all contracts entered into before May 1, 1917, were not to be interfered with. Exporters contend that they are protected by this provision, but the colliery companies reply that that particular provision applies only to the contract prices of coal, and it will probably require the ruling either of the Coal Controller or a court of law before the point is decided. The amount involved may be very considerable, for freights have varied from about 100*s.* in the case of Gibraltar to 190*s.* and more in the case of the Italian ports, and a third of 5 per cent. on a Gibraltar freight represents 1*s.* 8*d.* per ton, *i.e.*, 6*d.* to the exporter and 1*s.* 2*d.* to the colliery. Many side issues are also raised.

Italian Coal Pooling Scheme.—A meeting is to be convened of Cardiff exporters of coal to Italy to consider the suggested rules for carrying out the pooling arrangement in connection with the limitation scheme for the supply of coal to Italy. The principle of a pooling scheme was adopted by a large majority at a meeting held a few weeks ago, and the rules now proposed have been given the form in which it was understood at that meeting they should be drafted. They may not, however, be adopted in this form. In some quarters, for example, it is thought that a fairer basis of distribution would be one covering a longer pre-war period than 1913. The period now suggested is January, 1913, to October 31, 1916, and the view held by some exporters is that the period should be extended to 1910. The choice of November 1, 1916, as the operative date of the scheme is also a matter of controversy. The course of the Italian trade and the sharing of the Italian export business since the war has been altered very considerably, and the fixing of the operative date is for this reason a question in which financial interests are predominant, and which, therefore, brought the interests of some firms in conflict with those of others. It must remain with the proposed meeting to deal with these difficulties, but it is of interest to note that in 1913 the monthly shipments of Welsh coal to Italy averaged about 460,000 tons, in 1914 about 420,000 tons, in 1915 about 265,000 tons, in 1916 about 210,000 tons, and this year probably between 150,000 and 170,000 tons per month. The pool will only affect the exports other than those definitely allocated to the Italian State authorities.

Welsh Miners and their House Coal.—Under old customs the South Wales miners continue to be supplied with house coal at an average pit-head price of less than 6*s.* per ton. A company supplying about 10,000 tons of coal annually to its employees for household consumption at about 5*s.* 6*d.* per ton has recently ascertained that the supply of large coal at this price involves it in a loss of approximately 10,700*l.* per annum, the cost of production at this colliery being about 26*s.* per ton.

NEW DANISH SHIPYARD.—Another new shipyard concern has been formed in Copenhagen, with a representative board and a capital of £84,000. A favourable site has been obtained at Frederickshoim on some land filled up by the harbour authorities, the site in question having been rented for a period of 40 years. The new yard will principally undertake the building of steamers and motor-driven vessels of moderate dimensions.

THE INSTITUTION OF ELECTRICAL ENGINEERS: DISCUSSION ON THE METRIC SYSTEM.—As the subject of the Metric System was very fully discussed at the Institution of Civil Engineers in the early part of the year, more especially from the standpoint of the relative merits of that system and the British, it may be well to state that the main object of the Institution of Electrical Engineers' discussion, to be held on Thursday, December 13, is to consider the effect on the British electrical trade of the introduction of the Metric System at the present time, more especially in those markets in which the British system is at present in vogue, with a view to determining whether the compulsory introduction of metrical measures should be pressed for or resisted. It is hoped that it may be found possible to take steps after the discussion to obtain some authoritative pronouncement on the matter from the trade as a whole that will put an end to the present hesitating and unsatisfactory attitude towards the question.

KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE; GREAT CENTRAL RAILWAY.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(*For Description, see Page* 541.)

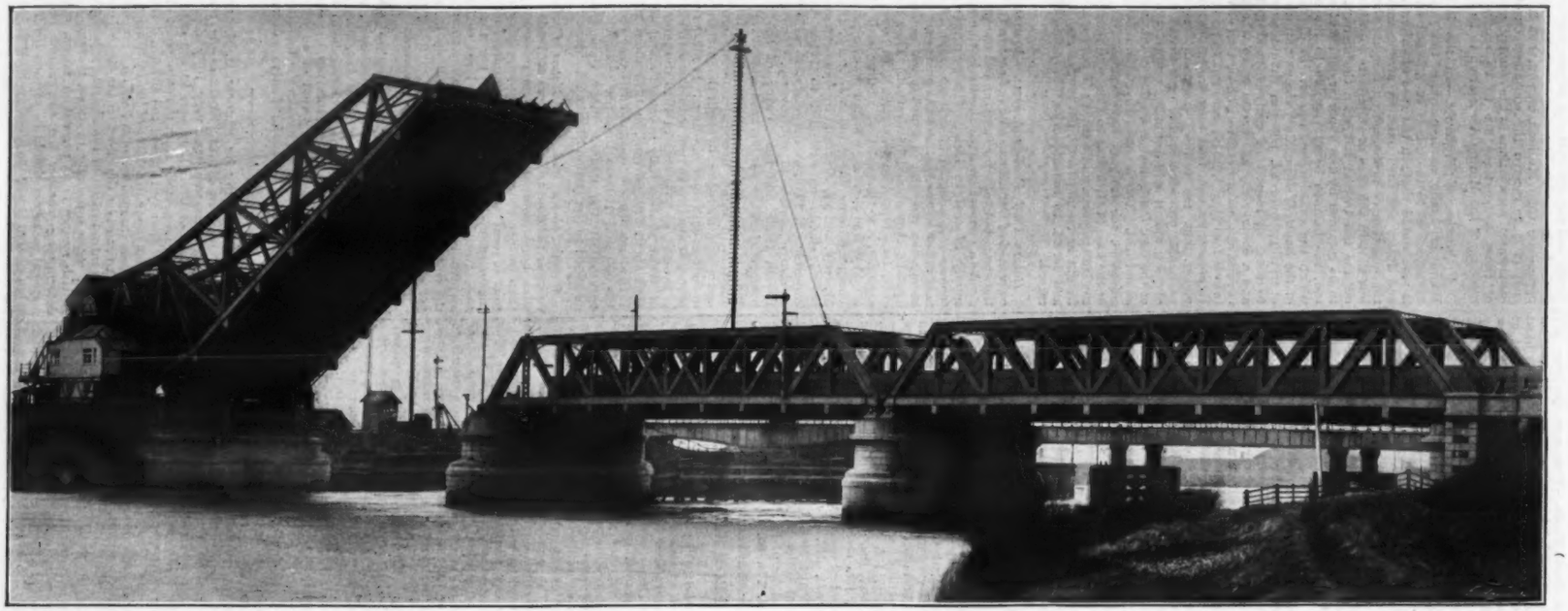


FIG. 61. THE BRIDGE COMPLETED; THE SCHERZER SPAN BEING RAISED.

GAS-LIGHTING ON THE SLOT-METER SYSTEM.—In the course of his address to the Institution of Civil Engineers, on the 6th inst., Mr. Harry Jones, the new president of the Institution, stated that to-day in the London district 70 per cent. to 80 per cent. of the gas consumers were working people using automatic slot meters, and they took upwards of 35 per cent. of the total output. In the large provincial towns the figures were rather smaller, there being 40 per cent. slot-meter consumers, who took over 20 per cent. of the gas consumed. These figures were rapidly growing.

GAS BAG TRAILERS.—The Joint Committee of the Commercial Motor Users' Association, the National Gas Council, and the British Commercial Gas Association, which was recently set up to encourage the use of gas as a fuel for motor traction purposes, has soon attained success in its initial efforts. At its first meeting it decided to make representations to the Local Government Board urging the expediency of allowing the legal speed of any vehicle when drawing a trailer used only to carry a gas container, to be such as if no trailer were so drawn. The Joint Committee has now been officially informed by the Local Government Board that an Order is being prepared "for altering the heavy motor car regulations so as to facilitate the use of trailers behind heavy motor cars for the accommodation of gas-holders containing gas for purpose of propulsion." A first list of gas charging stations will shortly be published, and the Hon. Secretary to the Joint Committee, Mr. Frederick G. Bristow, F.C.I.S., 83, Pall Mall, S.W. 1, will be pleased to receive details of further stations for addition to the list, giving information as to price of gas, size of connection, and hours during which containers can be filled.

MARKETS ABROAD FOR BRITISH AND IRISH GOODS.—The Department of Commercial Intelligence is compiling an index or directory of British and Irish manufacturers which it is proposed to forward to Trade Commissioners, Consular Officers, and other correspondents of the Department abroad, for their own use in dealing with inquiries which they may receive, for the supply of British and Irish goods, both now and for delivery after the war. A large number of firms have already supplied information as to their products to the Department, but before transmitting this information abroad it is desired that all manufacturers in the United Kingdom interested in the export trade should have an opportunity of applying for the inclusion of their names in this index. The Department is now compiling the sections of the index dealing with the following trades:—China and earthenware trades, glass trade, basketwares, woodwares, brush trade. Manufacturers in these trades in the United Kingdom are invited to supply, in letter form (*a*) a detailed list of the articles they manufacture for export; (*b*) a list of the foreign and colonial markets in which they are more especially interested; (*c*) the names and addresses of their overseas agents; (*d*) terms of business, such as, whether their trade is done direct with buyers, or agents abroad, or through merchants or agents established in the United Kingdom; and (*e*) any other information likely to be of use in enabling enquiries from persons desirous of purchasing goods in the United Kingdom to be dealt with adequately. The particulars should be sent to the Department of Commercial Intelligence, 73, Basinghall-street, London, E.C. 2. Envelopes should be marked "Index." The index is not intended for publication, but is for official use only in the Department of Commercial Intelligence, and by His Majesty's Trade Commissioners, &c. It is not proposed to insert trade advertisements.

"AIDS TO PREVENT A SHIP FROM SINKING."—A paper with this title was read by Mr. Chas. V. A. Eley at a meeting of the Institute of Marine Engineers on Tuesday evening, the 13th inst., and the discussion was adjourned until December 11. Mr. Eley considered, first, the air-pressure system, which he did not think suitable to meet the various kinds of damages to ships, and not therefore to be recommended as a permanent fitting in the ship; second, the Brunton system, with which our readers are familiar; and, third, the Eley system. This latter, according to the author of the paper, deals mainly with direct pumping combined with central means of indicating the position and amount of damage, central means for operating the pumps and for levelling the water in the ship for keeping a level keel. Collision mats of a special character may also be used. In connection with the use of this special apparatus it is proposed to train certain of the ships' engineers to act as "salvage engineers," who would go to their station when the vessel was in trouble or when in a danger zone just in the same way as a "gunner" would go to his station. The salvage engineers' station would be a small compartment in the most invulnerable part of the ship, say about 12 ft. or 15 ft. long by 6 ft. or 7 ft. wide. On one of the longer sides, about 6 ft. above the deck, a flat sectional model of the ship would be placed with slides to operate vertically as indicators to show at a glance if water was building up in any compartment, and at what rate. Just below each compartment of the model it is proposed to place the means for starting the pumps fitted in each respective compartment. On the deck, close up to the side of the compartment where the model is placed, there would be fixed a system of levers, almost like the levers in a railway signal-box, one for each compartment of the ship. Such levers would control the opening and closing of the valves to be operated for levelling the water in the ship, preferably through the double bottom where such exists. If the pumps in a flooded compartment were not sufficient to handle the water entering it, those in successive compartments would be brought into action. If the damage were too great for the pumps in the ship to deal with the whole quantity of water entering it, one, or perhaps two, damaged compartments even might be permitted to flood whilst the water was being kept out of all of the other compartments and the damage, except the damage in the two flooded compartments, "made good." Then the two flooded compartments could each be treated in the same way if possible. Mr. Eley described his system in detail, and entered upon a consideration of the question of adequacy of pumping plant, giving particulars of cost, weight and capacity. In the case of a large Atlantic liner, for instance, he spoke of an installation to get rid of 3,500 tons of water per minute.

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(*For Description, see Page* 541.)

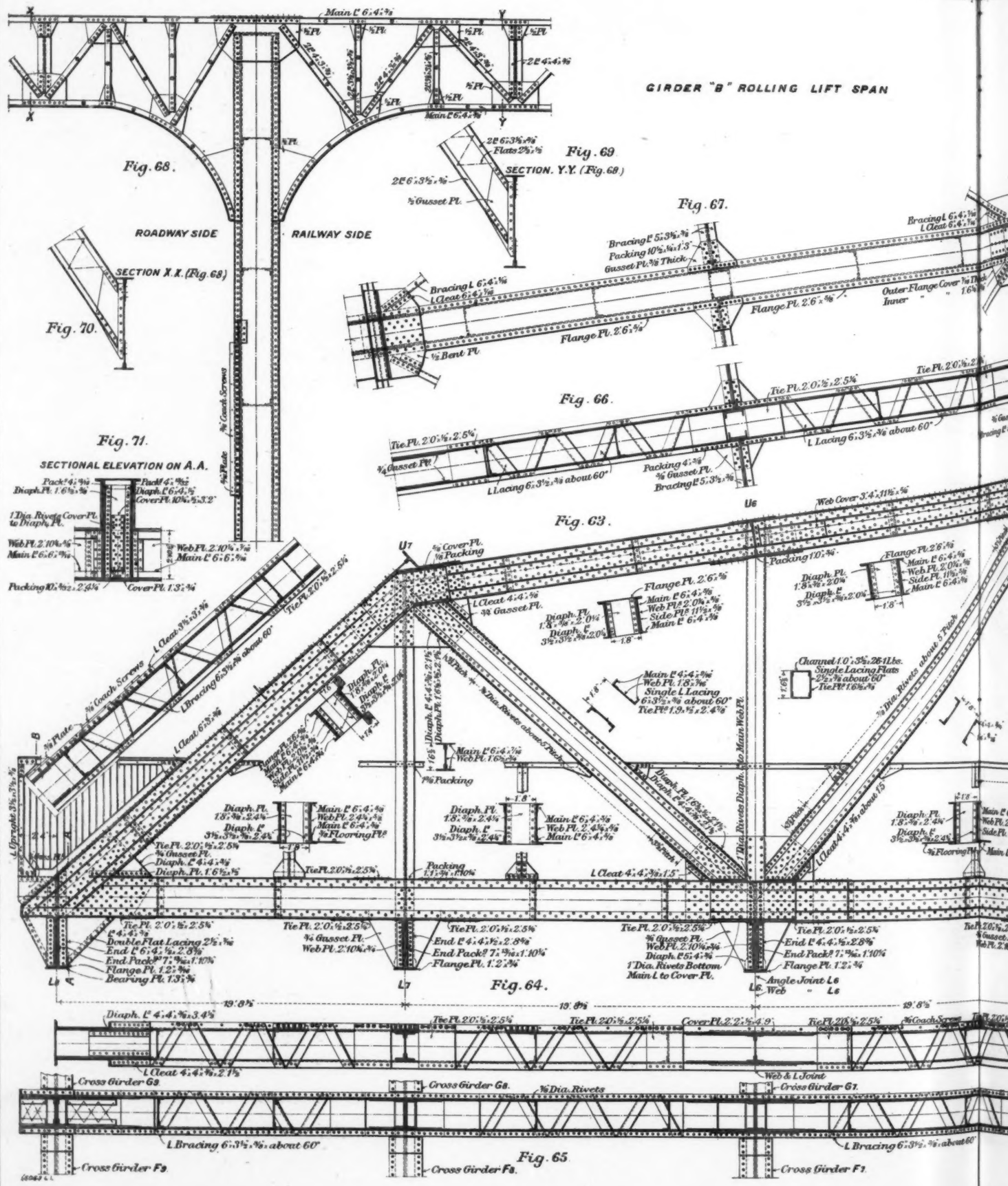
FIG. 62. SCHERZER SPAN BEING LOWERED.

(*To face page* 542.)

THE KEADBY RAILWAY AND HIGHWAY SCHERZER RO

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM AR

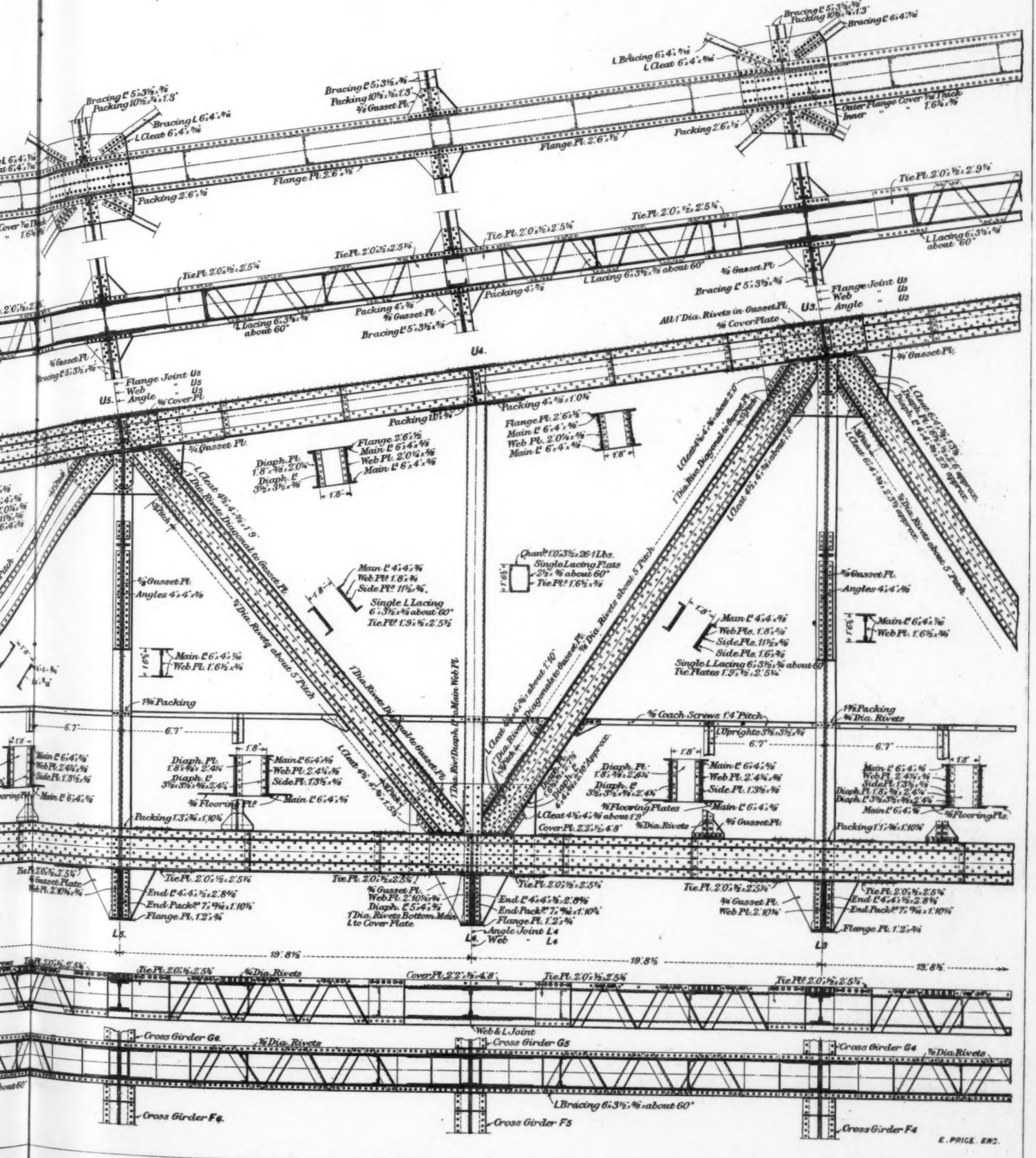
(For Description, see



ZER ROLLER LIFT BRIDGE; GREAT CENTRAL RAILWAY.

R WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(For Description, see Page 541.)



KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE; GREAT CENTRAL RAILWAY.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

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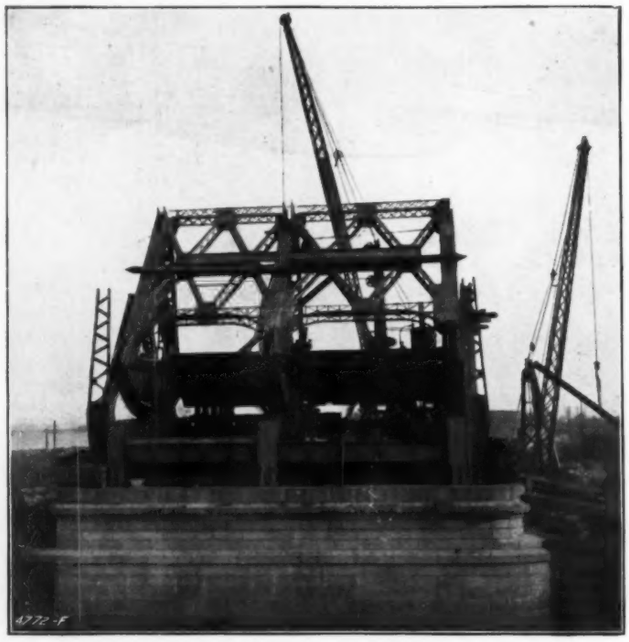

FIG. 72. ROLLING SEGMENT OF LIFT SPAN ERECTED FEBRUARY 23, 1915.

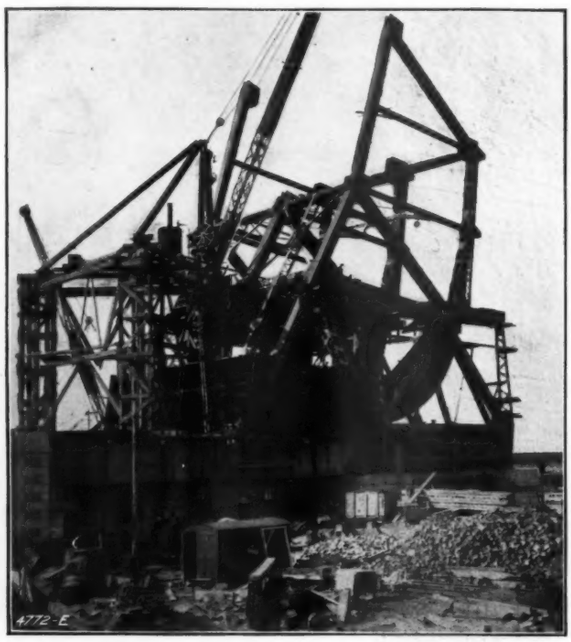

FIG. 73. LIFT SPAN MAY 14, 1915.

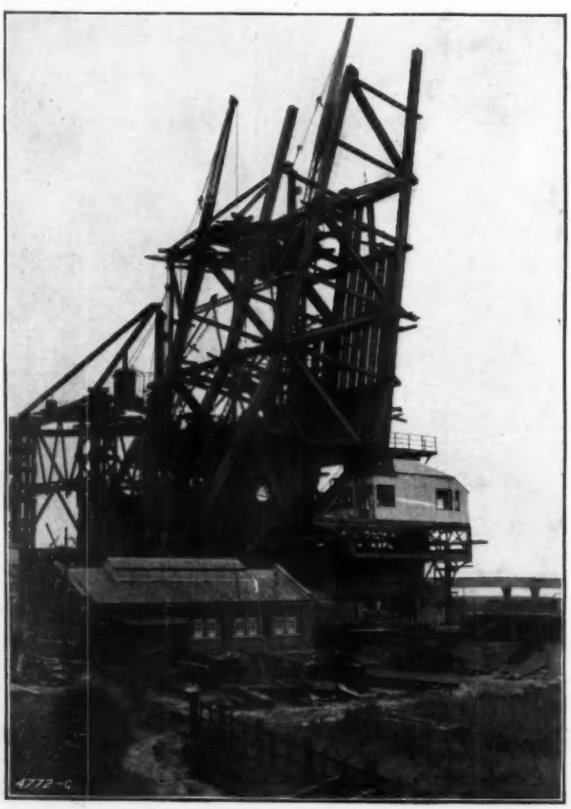

FIG. 74. UPPER PORTION OF LIFT SPAN IN PROGRESS, JULY 22, 1915.

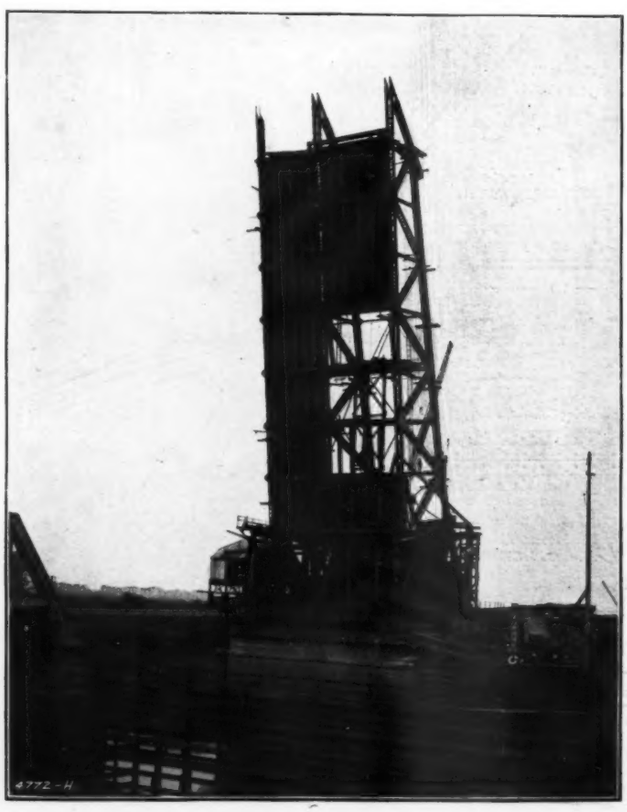

FIG. 75. LIFT SPAN NEARING COMPLETION, SEPTEMBER 24, 1915.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3063 and 8598 GERRARD.

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With One Two-Page Plate and Two One-Page Plates of the KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE; GREAT CENTRAL RAILWAY.

NOTICES OF MEETINGS.

THE CONCRETE INSTITUTE.—Thursday, November 22, at 7 p.m., at Denison House, 296, Vauxhall Bridge Road, Westminster, S.W. 1 (close to Victoria Station). Annual general meeting. To be followed at 7.30 p.m. by a paper by Dr. J. Newton Friend, D.Sc., on "The Corrosion of Iron and Steel, with special reference to Reinforced Concrete."
THE PHYSICAL SOCIETY OF LONDON.—Friday, November 23, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W. Agenda:—(1) "Some Problems of Stability of Atoms and Molecules," by Professor J. W. Nicholson, M.A., D.Sc., F.R.S. (2) "An Exhibition of the Uses of Certain Methods of Classification in Optics," by Mr. T. H. Blakesley, M.A.
THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 30, at 6 p.m., at the Institution of Civil Engineers. The Thomas Hawksley Lecture, "Heat Engines," will be delivered by Captain H. Riall Sankey, C.B.
THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, November 24, at 6.30 p.m., in the Assembly Room of the Cycling Club. A paper on "Our Sources of Energy, and Some Possibilities in connection with their Fuller Utilisation," by Mr. W. H. Watkinson, M.Eng., Professor of Engineering, Liverpool University.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, NOVEMBER 23, 1917.

STANDARD MERCHANT SHIPS.

WE have the official pronouncement (1) that the number of enemy submarines destroyed during the past ten months was double that for the whole of the previous year; the past three months accounting for as many as in 1916, or, in other words, that from 40 to 50 per cent. of the German submarines commissioned and operating in all seas has been sunk; (2) that the monthly merchant ship tonnage loss is now one-third less than that of April, the last week showing the smallest loss of any week this year, and that the net reduction during the past four months is 30 per cent. less than was anticipated in an estimate prepared for the War Cabinet early in July; and (3) that the output of new merchant ships from British yards will be more than twice that of last year. These facts show that the submarine menace is steadily being overcome.

The first achievement must take primary place, because thereby will the evil be minimised. Thus the naval and military authorities responsible for this phase of the war do well to concentrate attention on offensive measures; nevertheless it is important that the resources of merchant shipbuilding yards should be utilised at their highest efficiency. This requires systematic control, so that each yard shall be called upon to construct those vessels for which its berths and mechanical equipment are most suited. In the second place it is of vital consequence that there shall be a definite co-ordination in respect of the distribution of material. In the third place, and above all, it is imperative that the man-power available should give of its best.

In dealing in detail with the whole question we place this third desideratum in the primary position because it is perhaps the least amenable to positive control. The workers in this country have, with some exceptions, done splendid service. The call made upon them has been continuous and excessive. The conscientious worker has undoubtedly felt the long tax on his physique; but others, unfortunately, have so regulated their effort as to influence the collective result. There may be reasonable excuse for the action of the latter under normal conditions, but it cannot be too often enforced that if we are to achieve victory, without which permanent peace cannot be realised, every worker in this country, however insignificant his or her contribution to the common aim, must realise that that contribution is as necessary as the most heroic or dangerous work of men at the fighting front. That we should be starved through the success of the savagery of submarine operations is unthinkable, but in the ultimate end we can only defeat German savagery by maintaining that fleet of ships by means of which alone our food supply can be augmented from over the seas. Thus the boy who heats a rivet and throws it to the riveter is as surely advancing the war as his fellow-worker who sets and throws his grenade over the top into the German trenches. We need merchant ships if we are to exist as a nation and to enforce the lesson of national liberty. The ranks of the industrial army have been depleted for the greater service and sacrifice; consequently it is the duty of all the remaining workers to exert their utmost effort and deny themselves any privilege in order to safeguard their families, their homes and their nation. And we are convinced that they will pull their whole weight and that the submarine menace will vanish with ever-increasing acceleration.

That the employers are doing their best effectively to utilise the effort of the manual worker can easily be established. It has time and again been shown how they have not only patriotically handed over their establishments, but relinquished their rights to full profits and their mental organisation, all to serve the national end. The biggest capitalist is but a labour leader in his own factory under State service. Thus the worker can be assured that the result of his strenuous work cannot profit his employer, but is an immense gain to the national cause. This point may once again be established by a consideration of the work done by the Government departments responsible for the building of merchant ships. When it was recognised—rather late in the day, it must be contended—that co-ordination in merchant shipbuilding was essential, five standard types of vessel were designed by the Merchant Shipbuilding Advisory Committee set up by Sir Joseph Maclay, the Shipping Controller; two of these types were 400 ft. long between perpendiculars, 52 ft. in extreme breadth, and 31 ft. moulded depth, having a capacity of 8,000 tons deadweight and with standard engines of 2,500 h.p. at sea. Another type was 331 ft. long, with a breadth of 46 ft. 6 in. and a depth of 25 ft. 6 in., having a capacity of 5,000 tons deadweight and engines of 1,900 h.p. The fourth type was 285 ft. long, to carry 3,000 tons deadweight, while the fifth type was 376 ft. long, carrying 7,000 tons deadweight.

When Major-General Collard was brought to the Admiralty and appointed Deputy Controller for Auxiliary Shipbuilding he was able to induce men of great experience in the construction of merchant ships to join his staff, and to give the nation the benefit of their knowledge and ability. A consequence was a broad inquiry into the capacities of all merchant shipbuilding yards, so far as size and types of ship were concerned. The result has been to develop the idea of standard ships, and the latest types projected are an oil-carrying vessel and a three-decked steamer of 450 ft. in length, 58 ft. beam, and 40 ft. in depth, to carry 10,500 tons deadweight. This last is the only ship propelled by twin-screw engines, but the engines adopted are of the 2,500 h.p. standard type used for all the larger ships already mentioned. It will thus be seen that the types satisfy practically all the requirements of the mercantile marine, and to those who look with some degree of apprehension on the probable shortage of passenger steamers after the war there may be consolation in the view that it should be possible to utilise the three-decker for the arrangement of staterooms, &c. Thus, although these vessels may not be so luxurious as the pre-war ocean liner, they will nevertheless serve the purpose as temporary passenger ships.

We do not propose to enter upon any criticism of the designs. As the practice of one district differs from another some criticism is almost inevitable. The Clyde has always favoured what is known as the "three island" type of tramp steamer; the North-East Coast, on the other hand, almost exclusively builds what is known as the "shelter-deck type." Of course each must suit the require-

ments of their owners, and much can be said in favour of each. Most of the standard types are of the "three island" class of ship, but the 10,500 tonners are of the "shelter-deck" type. Similarly there is room for wide variation in practice in regard to the details adopted in the respective yards even in the same district; many instances might be given, in all cases with sound reasons for pursuing such practice. It has been contended that there was justification for going on broad lines in standardisation; in other words, that each builder might have been left to work out his own details. The determining factor, both in ship and engine, was so to design the details as to economise time, material and labour. The department therefore laid down not only standard dimensions, lines, cross-sections and general arrangement, but standard details of all sections, and on this latter question there has perhaps been more personal criticism than on any other. The decision to have standard sections and standard thicknesses of plates is supported by the contention that by this means the maximum output was realisable from rolling mills. Thus, taking the five types of ships on which work has been progressing during the past months, there are only eight or ten sections, including angles, bulb angles and channels. Thus it has become easy to apportion the product of any rolling mill to the shipbuilder whose need is most urgent. Similarly with plates; but here the shipbuilder is permitted to use any length of plate which best suits his machine tools. In this connection it may be stated that there is now practically no competition for material by the various war departments. Co-ordination of demands has been effected. The supply is controlled, and the claims of merchant shipbuilding considered along with all demands by the militant services. But it may also be said, without disclosing any fact of help to the enemy, that at the present time the material requirements for the merchant service are looked upon with the highest favour.

In the general arrangement of the ship, as in the design of machinery, there has been discarded an enormous variety of fittings, which in many cases were merely excrescences conceived as the result of idiosyncrasies of the draughtsman, the designer or the representative of the shipowner. Indeed simplicity is one of the characteristics alike of hull and machinery. It is symptomatic of the growth of the democratic spirit that great attention has been paid to the crew's quarters. The men are berthed in cubicles, each with two bunks, and their feeding quarters are entirely separate. The heating, ventilating and lighting show great improvement on the pre-war conditions, and the cubicle capacity is in excess of that required by the Board of Trade rules. Any error made in this direction is on the side of excess, and if improvement in environment leads to higher status, physical and moral, of seamen and firemen, no one will take exception.

From what we have written it will be recognised that splendid work has been done by Major-General Collard's department; as we have said, criticism is only as to detail. It may be that the disorganisation of the special machinery in any yard, consequent on alterations in detail, would nullify the gain in time in the case of the first one, two, or three ships. But work is not to end with two or three ships, as it is incumbent upon the nation to build up within the next two or three years, or as quickly as possible, an immense new merchant fleet, and so effective has been the distribution of work that no yard is occupied on sizes or types of ships unsuitable to its capacity for rapid production, so that the organisation is simplified and the whole progress of the work systematised. Nor will the ships be unwelcome to shipowners, because they have been designed to secure economy in marine service. The hatchways have been made large in order to reduce the time required in loading and discharging cargo. In fact experience showed that it was possible to reduce the size of the hatchways in the first ships built. Nor has the submarine menace resulted in arrangements to ensure flotation at great expense to working economy. Measures have been taken into which we do not propose to enter at length. The communication between the shaft tunnel and the engine room has been completely closed, as experience showed that damage aft from torpedoes resulted too often in the engine room being flooded because the door of communication could not be closed in time. Escapes for trimmers, stokers and others have had special attention, and screw-down valves have been fitted in the bilge suctions at the bulkhead, so as to obviate the passage of water from one compartment to another. Many such points might be mentioned to show that the policy of the Department of the Deputy Controller for Auxiliary Shipbuilding is commendable, and to establish the view that, alike in organisation and control, much is being done to maintain the lines of communication for food supplies. We return, however, in conclusion, to the one factor which is the least certain, and as a consequence the most important, namely, the earnestness of the working classes. It cannot be too often enforced that in sacrificing personal inclinations, and in giving wholeheartedly the best of their mental and physical effort, to the limit of endurance, they are doing "a bit" as essential as that of the man in the trenches. They have not, however, the dangers, nor are they called upon to risk life or limb; on the contrary, they are invited and encouraged to earn the highest wage within their powers.

SCIENCE AND THE STATE.

It, would perhaps, be too much to hope that the politicians and lawyers who, as Mr. Wells has said, are likely to govern us to the end of time will read and digest the able and interesting address which Mr. Campbell Swinton delivered at the Royal Society of Arts last Wednesday in assuming the chairmanship of the council. To a large extent the errors made in the past in the treatment of technical questions, have arisen from the materialistic view of science and economics which has long been prevalent in what are commonly known as "progressive" circles, and Mr. Swinton has done good service in calling attention once again to the serious losses suffered by us in the past from this obscurantist attitude. It has been common for the politician to assume that the only interests to be considered in economics had relation to the distribution of wealth. Their action seemed to be governed by a theory of wealth essentially identical with that advanced by the Duchess in "Alice in Wonderland," who summed up the situation from this standpoint comprehensively and concisely with "the moral of that is, the more there is of mine the less there is of yours."

"To protect the consumer," the absurd Electric Light Act of 1882 was passed through Parliament, with the net result that for six invaluable years there were, as Mr. Swinton says, no consumers, since no sensible man ventured to invest his capital in an infant industry on the basis that he lost everything if it failed, whilst if success were obtained, the fruits of his courage and enterprise were to be confiscated to the community without any compensation whatever, the material values of the plant being alone subject to appraisal in any transfer to a public authority. Moreover, even when matters were slightly ameliorated by a later Act, possible profits were limited to a maximum insufficient to make it possible to finance highly-desirable experiments. As a consequence, we ceased as a nation to be responsible for any of the more important electrical developments, becoming importers instead of originators of novel ideas. An argument urged against the opponents to these Acts was that they merely desired an opportunity to make fortunes. The Acts did not, however, prevent fortunes being made, but they were made by the natives of other countries, to whom we paid enormous sums for ideas which under more favourable conditions we should have developed for ourselves. From a purely materialistic standpoint, possibly, it may perhaps matter little to the individual consumer, to whom he pays tribute for the benefit of ideas, but it matters much to the nation if opportunities formerly open to men of imagination and enterprise are closed by legislative action.

An eminent American engineer has observed that the acquisition by the State of the telegraph undertakings in this country was followed by an almost complete cessation in the improvement of telegraphic apparatus by British inventors. Up till that date, he said, more than three-fourths of the improvements incorporated in telegraphic instruments had originated in this country; and this continued to be the case with regard to submarine cable work; but so far as land telegraphs were concerned we became for the most part parasites on the thought of other nations.

To the politician or Treasury official it no doubt appeared the height of wisdom to adopt at the transfer as standard one particular type of apparatus and reject all others. Obviously, fewer spares need be kept, and certain other minor economies became possible. This purely materialistic view of the matter, however, disregards the enormous advantage of having independent and competing centres of design and invention.

In his address, Mr. Swinton recalls another instance in which our politicians interfered with engineers, and with disastrous results. He observed that mechanical traction on highways made rapid progress in this country between 1820 and 1836. Towards the close of this period many steam-coach services were regularly maintained between various centres in different parts of the country. Legislation was then passed destroying this form of enterprise, and it would be an interesting question for some of the statistical economists to form some estimate of the consequent loss of wealth. to the country.

It is frequently assumed that to-day matters have materially improved, "*Mais plus ça change, plus c'est la même chose*," and we understand that even in the Munitions Ministry the old Adam has reappeared, and that it is a standing rule that no engineer shall be present at any conference between the department and trades union officials, the negotiations being conducted on behalf of the department by lawyers or schoolmasters. The reason given is as ingenuous as that of the rural magistrate, who expressed a preference for deciding causes brought before him immediately after the plaintiff had given his evidence, and without calling on the defendant, whose evidence had, he stated, been found in his experience merely to complicate matters. Similary, the department's representatives find that experts are likely to traverse claims made by the union officials, thus complicating an apparently straightforward case. Probably no important improvement in the efficiency of our Government services will be effected until they are made less open to the "Oxford Greats" man, and are recruited more largely from classes of wider culture educated on less narrowly specialised lines. Mr. Swinton instanced the necessity of this reform as an argument in favour of a more general teaching of science. He observed very truly that a large proportion of the great advances made in both pure and applied science had been due to men who had little advantages in the way of academical training. Possibly this will always be the case, but for one "revolution" we have hundreds of reforms, and it is in the working of this very large field of "improvement" as opposed to "invention" that we have been seriously handicapped in the past by a lack of adequately educated staffs. At the same time it is as Mr. Swinton pointed out, essential that works proprietors shall themselves be properly educated, lacking which they will fail to appreciate the fact that whilst a reliance on past experience may be adequate for the immediate needs of the day, a thorough understanding of scientific principles is essential for economically facing the novel problems that may arise on the morrow.

Mr. Swinton also drew attention to the tendency of certain workers in pure science to underrate the value of the part played by those who adapt new discoveries to practical ends. To a large extent the pursuit of pure science is its own reward. The work is intensely interesting, and its devotee, even if he does not make a fortune out of it, avoids at the same time the risk of losing one. Lord Masham, for example, is said to have ventured nearly a quarter of a million before he attained success in the utilisation of silk waste. The problems of applied science are probably every whit as difficult as those of the physicist, and over and above the laborious days and restless nights

due to the purely physical aspect of his problems, the inventor has generally also to face serious financial worries. Mr. Swinton pointed out the unreasonableness of the somewhat heavy patent fees still demanded in this country, in view of the fact that they go merely to swell the general revenue. Were the patent office surplus spent on scientific education, scientific libraries, and the like, there would be less to be said against the present scale, any material lowering of which might possibly give rise to a large increase in the number of "fishing" patents applied for. Patents of this kind are taken out by men who are incapable for one reason or another of developing their "half" ideas into "whole" ones, but hope to mulct at some future date some man of greater ability who succeeds in making a really effective solution of the problem in view. Of this there have been frequent instances in America.

OIL PROSPECTS OF THE BRITISH ISLES.

When bringing the question of "Petroleum in England" last winter* before the Institution of Petroleum Technologists, Mr. W. Forbes-Leslie marshalled up what he considered strong evidence in favour of the probable existence of free oilfields in certain districts of England, especially in the eastern depression. Meanwhile a mild oil-fever has once more broken out, and wholesale drilling for oil is largely advocated and urged upon the Government. When the question came before the same Institution again last Tuesday, Mr. W. H. Dalton, F.G.S., F.C.S., of London, late of the Geological Survey, in presenting his paper "On the Oil Prospects of the British Isles," made it clear from the outset that he is opposed to the widespread conception of a store of petroleum of commercial value lying intact within the limits of the British Isles. He dealt with the problem as a geologist, and his colleagues, who took part in the discussion, as well as the chairman, Mr. Charles Greenway, and Sir Boverton Redwood, who spoke as petroleum technologists, agreed that Mr. Dalton's exceptional experience as a petroleum geologist fully entitled him to pronounce an opinion. Like Mr. Forbes-Leslie he concluded with the statement that the drill and pump constitute the final court of appeal. But he was far from suggesting general drilling on the chance that something might be discovered. In fact, drilling seemed to appeal to him more in the general geological interests than in the expectation of finding oil or oilfields. Replying to the discussion he remarked that, if borings, a quarter of a mile apart should fail to disclose oilfields, the Press would call for bore-holes at distances of 200 yards; he repeatedly alluded to "wild-cat schemes" in his survey, and his tone was sharply sceptical throughout, a little more satirical possibly than the treatment of the oil-fever may render advisable. We will quote a few instances in a condensed form: "The facts should be at least of commercial purity; errors as to the quantity of oil exuding at a place as to pints and gallons, hours and weeks . . . are trivial. On the other hand, the representation as a natural flow of leakage of refined oil from storage is a grave deviation from verity, not necessarily intentional (any more than the leakage), but as reprehensible in respect of carelessness in the investigator as in the storekeeper who permitted the waste." Numerous cases of gross deception have, of course, occurred. Mr. Dalton referred to the denunciations, as an opponent of natural resources, showered down in 1903 upon Professor Cole for demonstrating, that the oil spring in a Dublin cellar was of this—just mentioned—unnatural character. Similar denouncements may possibly now be showered down upon Mr. Dalton himself.

In his survey Mr. Dalton confined himself to actual liquid petroleum, and did not much deal with the potentialities of distillation from so-called oil-shale, from coal, peat or other carbonaceous solids. He mentioned gas discharges and solid paraffins, asphalts and other "mineralogical curiosities, as bearing upon their possible accompaniment of liquid oil of which they may be external desiccated residue left by oxidation or evaporation of volatile constituents." Perhaps he dismissed too curtly the possibility of the assumption that any but a minute proportion of oils might be due to purely inorganic reactions, considering that the key to the natural formation of petroleum from organic matter remains to be discovered. The physiologist rightly insists that Nature does not apply violent laboratory reactions, but so far as the geologist is concerned, Nature might conceivably work laboratory processes, hugely magnified as to the time scale particularly. Mr. Dalton, of course, dwelt on many instances in which oil-bearing strata have, by the intrusion of igneous rocks or volcanic action, been metamorphised, the hydrocarbons having been coked or graphitised and the gases having probably escaped under subsequent disturbances, or imprisoned in some crevice not yet reached by the miner. But he also referred to cases in which the heat transmission has been peculiarly restricted. Whilst 300 ft. and more of burnt strata have been pierced at Nether Dechmount in the Lothians, a basalt sill at West Calder, 261 ft. thick, has burnt the subjacent beds for only 6 ft., a good oil-shale lying 10 ft. lower; a 5-ft. sill at Broxburn has had no effect at all on the oil-shale 8 ft. below it, and a sill of over 10 ft. thickness, destroying a shale 6 ft. above it, had no action on another 8 ft. higher.

We have already passed into the detailed review of specific instances of actual petroleum occurrences in the British Isles which formed the main part of Mr. Dalton's communication. He proceeded on geological lines, from the oldest formations upward. A viscous tar, often consolidated into albertite, was found in the Old Red Sandstone of Dingwall, descending sometimes into the crevices of the subjacent gneiss. Petroleum vaguely reported from the Orkney mainland, from Cupar in Fife, from Torquay, from Willesden, &c., was apparently —two very doubtful cases—of the same or Devonian age. Occurrences in the succeeding carboniferous series were much more frequent, not so much perhaps from conditions of formation, though the fauna and flora were more frequently well preserved, as from the extensive mining operations which revealed pockets of oil where none was seen on the surface. Mr. Dalton referred in particular to the oil-shales of Broxburn, &c., in the Lothians, in the calciferous sandstones of the lowest member of the carboniferous series. The next division of the carboniferous was constituted by the Yoredale beds, in which the notorious black-oil flow at Norton (near Stockton-on-Trent) was observed. The next member, the mountain limestone, contained the elaterite or mineral rubber, of Windy Knoll, Derbyshire, exuding from a low knoll after summer rains as a yellow tar, rapidly turning brown and brittle. The asphalts, oil and gas of the district, the hot springs of which indicated continuance of chemical action, were of doubtful original position. The Ashwick Court oil near Shepton Mallet, of which much had been made last winter, came from the upper carboniferous, but the occurrence was mysterious. The millstone grit, following in geological sequence, contained the unique flow from the Kelham boring near Newark; this oil seemed to be indigenous to the rock in which it was found. In the coal measures themselves natural and artificial emanations of hydrocarbon gas were abundant, the gas being partly set free by mining operations. Fluid petroleum oozed out from faults or dripped from the roofs of several coal mines; but most of the reports were vague and exaggerated, and it had to be borne in mind that a roof implied a change in conditions from terrestrial vegetation to subaqueous deposit of sediment. That was sometimes brought about by subsidence and invasion of an area by the sea, and if petroleum were mainly due to marine organisms, the roof of a coal seam seemed to be a watery paradise for the development of oil-making organisms. Detailing oil finds and gas jets reported from coal mines, Mr. Dalton drew attention, among other features, to the frequent presence of fish remains and marine fossils.

Dealing briefly with the occurrences of oil in younger formations, Mr. Dalton pointed out that in the permian and triassic, salt and petroleum were associated in England as on the Continent. The jurassic clays were frequently charged with bituminous matter, and gas and free oil had been reported from many localities, whilst the English cretaceous and tertiary beds were devoid of traces of hydrocarbons. As regards the post-tertiary epochs, the oils in the peats of Down Holland (Lancashire) and in several extensive Irish bogs seemed to be a native petroleum; the saturation of the peat with water was not necessarily an insuperable obstacle to its utilisation.

Conoluding, Mr. Dalton then remarked that, though the Kelham and Norton instances demonstrated the possible occurrence of oil in deep-seated portions of series, of which the wide areas of outcrop yielded no similar indications, it was much to be doubled whether in any part of the secondary rocks and in the subjacent palæozoic series there existed any deposit of commercial value commensurate with the cost of wild-cat search. In the British Isles, as in other parts of the world, oil-forming conditions had frequently recurred, but to a very limited extent; and although conditions favouring the accumulation of oil, and tectonic structures capable of conserving it from escape were also of frequent occurrence, the conjunction of the latter essentials with original formation had generally failed. The feeble and short-lived flows which British rocks exhibited, necessarily conformed to the hydrostatic laws of vast bulks of other regions; but, whether from defect of original formation, of space accessible for accumulation, or of adequate seal from escape, the total result was from a practical point of view valueless, except possibly in the one or two cases mentioned.

The term "wild-cat" was, in the instance just quoted, not too strong, Mr. Dalton considered, in view of our ignorance of the tectonic structure obtaining in the older rocks, especially to the eastward of proven positions. But his remarks, that no extensive area in England had escaped the test of drill or pick, and that to geologists negative evidence in respect of petroluem would be of much value, called forth criticism which will not have surprised him. Those words must, however, be understood in the sense we indicated in our introduction. In a certain way the cases of gold and petroleum may be regarded as similar. Both these substances are common, and yet rare. No miner would drill for gold, however, on the mere chance, without having previously consulted geologists. Geologists are no more infallible than other experts, of course, and Mr. Cuningham-Craig indeed differed from Mr. Dalton as to the interpretation of certain features, and he also took a less pessimistic view, while Mr. Forbes Leslie wanted to drill, and go down to 3,000 ft. and more, because there had once been oil, and he wanted to find out whether there was still oil. The other geologists—Mr. G. Barrow, Mr. V. C. Illing and Mr. D. A. Sutherland—thought it necessary to send out a note of warning to the public or at least to throw cold water on high expectations. Mr. Illing in particular pointed out that England—Mr. J. Ford had remarked, he did not see why England should be less favoured as to petroleum than other countries—did not differ from most other countries. There had once been petroleum in many spots; but faulting, denudation, erosion of anticlines and other factors had left little of it, and drilling in the eastern and southern districts had not been so infrequent as some speakers had suggested. They certainly did not agree with Sir Boverton Redwood, who was practically pleased only with Mr. Dalton's last words, already quoted, that the drill and pump constituted the final court of appeal, because the country had to be made independent of the foreign supply of so important a product, nor with the chairman's "summing-up" in one sentence to the same effect. The country has enough to bear at present without being saddled with the expense of chance drilling.

* See Engineering, January 19, 1917, page 59.

NOTE.

German Technics and Economics.

A translation from a German paper, prepared by the instructions of Sir Robert Hadfield, states that the "German Union of Technical Scientific Societies," which has been formed by the

combining of 13 associations, recently held its first general meeting at the premises of the Association of German Engineers, when the chairman, Privy Councillor Busley, after welcoming those present, among whom were members of the Imperial Government Departments, explained the aims and purposes of the new Union. Herr Busley said that the object in view was to establish a balance between science and practice. Many a technical task could not be carried through without the collaboration of several branches of science; for example, the metallurgists required the co-operation of the technician, the architect that of the engineer, and so forth. It was intended, further, that influence be exerted on technical instruction, and also towards ensuring that the academically-trained technician be admitted to all administrative departments of the Federal States. The technical world ought to be represented more than was hitherto the case in legislative bodies. The "Union" had also applied to the authorities with a view to being consulted in the preparatory work of drafting regulations or enactments. Unfortunately, the Imperial Treasury alone had hitherto availed itself of technical expert advice, in the preparatory work for the taxation of coal and sources of energy. Herr Busley also stated that a desire had been expressed for incorporating in the "Union" an Austrian and Hungarian section; with regard to this latter point resolutions were still to be passed. Professor Dr. Wiedenfeld (Halle) then spoke on "Economics and Technics during and after the War." He showed exhaustively how in former days Germany was able to manage with her own resources alone; she subsequently became more and more dependent upon foreign countries by reason of the increase of her population, and ultimately, owing to the blockade of the sea she had been compelled to remodel all the foundations of her economic life. Technical science, he said, could only meet the new requirements set up by fundamentally disregarding the question of cost price which formerly, in competition with other countries, was one of the foremost considerations. Substitutes were produced by calling in the aid of new methods of manufacture and by directing thereto all the human powers available. A part only of the new conditions and products could be carried over into the times of peace; in other words, he added, the old economic conditions could not be reverted to in their entirety, nor would this even be desirable. Technical science, he further stated, had been endeavouring to come to the aid of economical life in a threefold manner: (1) In the matter of raw materials, by re-establishing industries which had become unremunerative (production of manganese, increase in the production of iron, production of sulphur, intensification of agriculture, &c.); (2) promoting the technical tendency, which existed already in pre-war times, towards an increased utilisation of waste products (obtaining lubricants from coal-tar, utilising waste material for clothing, &c.)—the term "non-utilisable substance" had been eliminated by the war; (3) producing substitutes (nitrogen from the air, obtaining substances by synthetic processes, &c.). In the speaker's opinion, too much regard had been paid during the early part of the war to quality of production; a condition which, however, became impossible to carry out with the continued duration of hostilities. He found fault with the multiplicity of Government controlling authorities, which had also manifested itself in peace times to the prejudice of German production. He claimed that after the war Germany should continue to aim at a restricted use of certain raw materials. Production would assume an unfavourable aspect in certain departments owing to the high cost of industrial war installations, and the amortisation of these during the war was a necessity.

Openings for British Articles in Italy.—The British Chamber of Commerce for Italy has issued list No. 34 of Italian firms who are seeking connections with British firms for business now or after the war.

Electrically-Operated Locomotive Turntable.—The overhead current-collecting device referred to on page 385 *ante* is fitted with Skefko ball bearings, and not with roller bearings, as stated in error.

THE INSTITUTION OF MECHANICAL ENGINEERS.

A well-attended ordinary general meeting of the above Institution was held on Friday last, the 16th inst., at 6 o'clock p.m., at the Institution of Civil Engineers, Great George-street, Westminster, Mr. Michael Longridge, the President, occupying the chair.

Air-Lift Pumping.

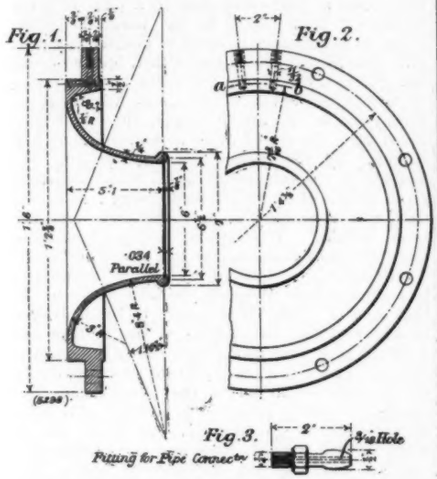
A paper entitled "Some Notes on Air-Lift Pumping" was read in abstract by the author, Mr. A. W. Purchas, of Wolverhampton, Associate Member, and was subsequently discussed. We commence the publication of this paper in full in another part of the present issue (page 561), and accordingly proceed to the discussion.

Mr. E. R. Dolby commented upon the very careful way in which the author had made the tests upon which the paper was based. Speaking as a consulting engineer, he would say that he had had no experience of such a large installation as that of the California Oil Fields, having chiefly been concerned with air-lift pumps for hospitals, workhouses and large office buildings. To such installations, however, the same principles and details applied. He had been forced to the conclusion that it was absolutely essential to put down an experimental plant in the first place, so as to be satisfied as the volume of water to be raised, and particularly as to the fall of the water level during pumping operations. In the case of the California Oil Fields, the fall of the water was only about 10 ft. or 11 ft., whereas in his experience this fall had sometimes exceeded 100 ft., which, of course, affected the design of the installation. He assumed that the words "submergence" and "submersion" used by the author were synonymous. In the book by Mr. Ivens, mentioned in the paper, "submergence" was defined as the vertical distance between the static level of the water and the point at which the air pipe entered the eduction pipe. The speaker was under the impression, however, that the author used "submersion" to connote the difference in vertical height between the level of the water when it had attained its permanent position in pumping and the point at which the air entered the eduction pipe. He assumed, moreover, that the author calculated the total lift from the water level assumed after pumping several hours and the level at which the water was delivered to the tank. (Mr. Purchas here informed Mr. Dolby that by the term "submersion" he meant the distance from the level of the water in the well, when the well was pumped at the capacity of each test, to the point of air injection, and similarly the lift would be the distance from that same water surface, when the pump was working, to the extreme uppermost end of the eduction pipe. All the terms referred to the pump in operation). Continuing, Mr. Dolby said that that connotation was not the one signified by the word as used by Mr. Ivens. In support of his contention as to the advantage of putting down an experimental plant, the speaker gave the following particulars of an installation in the City of London, the installation having a 6-in. borehole 450 ft. deep, calculated from the floor of the well chamber, which was 18 ft. below the pavement outside. Chalk was reached at 240 ft. The 6-in. pipe was carried down 6 ft. into the chalk, whilst the eduction pipe was 417 ft. deep and 2 in. in diameter. The air pipe was 1 in. in diameter, and entered the eduction pipe 4 ft. above the bottom of the latter. The foot piece differed somewhat from that described by the author; no means of breaking up the air was provided, the air simply issuing from the 1-in. pipe into the eduction pipe. Before pumping, the static water level was 187 ft. below floor level; the pumping level, after pumping had been going on for some time, was 290 ft. below floor level. At starting, the air pressure was 93 lb., gradually falling to 55 lb. The total lift was 298 ft., 8 ft. being required for lifting into the tank in the basement. The submergence while pumping was 127 ft. Calculated by the author's method, the ratio of submergence to lift was 0.76, distinctly lower than any of the ratios given by the author. He had had no opportunity of measuring the air in the way done by Mr. Purchas, and had to depend on the dimensions of the compressor. Mr. Dolby, in conclusion, desired further information relative to the differential pressure gauge mentioned by the author. He had himself had a differential gauge made to measure the difference between the pressures on the two sides of a pump when reinforcing the water circulation in a heating system, but he had never found, in the course of his experience with half-a-dozen such gauges, one that was satisfactory for any considerable period.

Mr. William Reavell, who spoke next, emphasised his appreciation of the fascinating subject which Mr. Purchas had introduced. The idea of lifting large volumes of water from a well without any machinery in the latter would always prove attractive to engineers. He regretted, however, a certain lack of precision in the author's references to air compressors and their efficiencies. Mr. Purchas, in his paper, had objected to the calculation of the volume of air used from the known displacement of the low-pressure piston of an air compressor allowing volumetric efficiencies of 95 per cent. and 97 per cent. In this connection the speaker would have been glad had the author branded as incorrect all methods of getting the volumetric efficiency either by displacement or indicator cards. It would appear from line 13 in the author's Table I, series C and D, that the volumetric efficiency of the air-compressor from cards approximated in all cases to 95 per cent. The designer of reciprocating engines was familiar with the extreme difficulty of getting a clearance at the end of the cylinder of smaller value than, say, 3 per cent. of the displacement. As it appeared from the paper that the diameters of the air cylinders were 10 in. and 18½ in., the delivery pressure in the first stage would be in the neighbourhood of 45 lb., or, say, 60 lb. absolute; and from the point of view of clearance alone, 12 per cent. would be lost, leaving the impossible figure of 88 per cent. to begin with. Leakage past the piston and past the valves was, among other things, a factor in marring volumetric efficiency. Again, in the case of compressors using suction valves, the atmosphere had to lift the valves to get into the cylinder, so that, with such spring loaded valves, the resultant pressure in the cylinder was, naturally, below atmospheric pressure; compared, therefore, with piston displacement the volumetric efficiency would be much less. For these reasons, he considered that it would have made matters simpler had line 13 in the table mentioned been eliminated. Mr. Reavell also condemned the indicator diagram method of getting volumetric efficiency. Steam consumption in a steam engine could not be computed from indicator diagrams alone, nor could the air used in a compressor be so calculated. The ideal diagram, to which compressor makers strove to approximate, was $P V = c$, but without efficient cooling the indicator card would show a curve more like an adiabatic curve. He had seen cards which indicated $P V = c$, the reason, however, being leakage past the piston, which flattened out the curve. But a worse curve than that of adiabatic compression resulted when the delivery valves were leaking, air pressing into the cylinder from the delivery side until the pressure practically reached delivery point. Further, the suction line might not correspond to the atmospheric line, but be considerably below it, by reason of the pressure on the suction valves, as already stated.

On the question of the volumetric efficiency of the compressor, the author had set out the considerations taken into account in assuming the values for the tests A, B and C. If, the speaker said, Mr. Purchas were measuring by the volume of air flowing through the orifice, *i.e.*, the delivery air, he (the speaker) could not understand how considerations numbers 2 and 5—the known condition of the air valves and guides and the known condition of the scale in the cooling jackets—affected the question, since the volume of air flowing through the orifice was the air actually dealt with by the compressor. These considerations would, of course, come into play if the measurement were effected by testing the volume of air drawn into the compressor. Mr. Purchas had referred to the meter used by Professor Durley, and this method of measurement was of great interest to all desirous of knowing the volume of air under pres-

sure actually passing through a pipe. The interest would be increased, he thought, if the author would add the actual size of the orifice, and so enable computation to be made from the diagram. With regard to Fig. 6 in the paper, showing the orifice type of high-pressure air-meter, he would urge that it would make for simplicity in using both the formula and the apparatus indicated by the author, if the nozzle formed by a plate with a hole in it was eliminated, a nozzle with parabolic curves being used, as shown in the annexed illustrations, Figs. 1 and 2. In this case the pressure at the front of the nozzle would be measured through the ¼-in. hole *a*, and that at the back through the hole *b*. The outlet of each of these holes is tapped to receive a nipple shown in Fig. 3 for the attachment of an india-rubber pipe. Experience had shown that, so far as the discharge coefficient of such a nozzle was concerned, practical unity coud be obtained, whereas in the case of a hole in



an ordinary plate the coefficient was somewhere about 0.72. The fact that the nozzle he had just suggested would come within 1 per cent. of unity, removed a point of doubt. He would like the author to state what practical advantage was derived from having an "auxiliary air reservoir" at the foot piece; with regular motion of air down the tube and water moving upwards he could not understand the need for an air reservoir. In the case of a single-cylinder slow-speed compressor such a reservoir on the surface was desirable, in order to obtain even flow of the water. Mr. Purchas had also stated that the best machine was that which would deliver the required volume of air at the given pressure with the least expenditure of energy, and in this relation the author had pointed out the importance of temperature. Mr. Reavell suggested the substitution of "weight" for "volume," inasmuch as the volume must be corrected for atmospheric temperature. In conclusion, No. 2 of the paper, Mr. Purchas had stated that in air-lift installations the greatest loss was in the air compressor, and therefore the best compressor was none too good. The speaker would say that he was unaware of any type of machine in which the difference between good and bad was so marked as in the air compressor. Finally, in an air lift installation, where the greatest loss was in the machinery at the surface, it was of the highest importance to select a machine in which the brake horse-power applied to the shaft had the lowest value as compared with the actual weight of air compressed and delivered at the required pressure.

Mr. F. C. Paget, of the Isler Company, desired to add his congratulations to the author on his interesting paper, but he regretted that Mr. Purchas had spoken of air lift pumping as having fallen into disrepute. The speaker was ignorant of the state of opinion in connection with the Oil Fields of California, but could repudiate the author's suggestion so far as this country was concerned, seeing that air-lift pumps were put down in increasing numbers every week. Referring to the illustrations of the air injection foot-piece, Fig. 1, of the paper, series A, he noticed that, with the exception of the perforated holes round the side, the bottom of the air pipe was plugged, an arrangement having the disadvantage that any accumulation of rust in the air pipe would fall to the bottom and gradually choke up the foot-piece. The same objection applied to Fig. 2, and to Fig. 2A, series C, the author having apparently omitted a tail piece to the foot-piece. If that were not so, he should imagine that the air would have a tendency to flow downwards as well as upwards, especially at starting. From the points of view of clear air passage and clear waterway, the foot-piece illustrated by Fig. 3, series D, had advantages. In Table I, series D, of the appendix, giving data of tests, he noticed that 168 cub. ft. of free air was used per minute, this air being compressed to 132 lb.; this would be equal to about 15.5 cub. ft. of compressed air per minute. The author had assumed the air would be delivered through all the 120 ¼-in. holes, but the speaker believed that the small volume of air used would escape through the first three or four holes nearest to the air outlet and the air, instead of being delivered in emulsion, would be delivered in three or four streams. For commercial purposes, efficiency figures should, he considered, be taken for air-lift pump and compressor complete. Before buying an air-lift pump, with a quoted efficiency of 72 per cent., a possible purchaser would want to know the over-all efficiency which was the governing factor. Moreover, in comparing the air-lift and deep well pump systems, yearly running costs must be considered. In the case of the deep well pump repairs were necessitated owing to the wear and tear in the bottom portions, such repairs being in many instances very expensive. On the other hand, repairs were reduced to a minimum with air-lift pumps, only those being necessary which were required to maintain compressor efficiency. If, therefore, the efficiencies were taken over a number of years, he thought the air-lift pump would compete with the deep well type. The author would have added to the value of the paper by mentioning some of the advantages of air-lift pumping. For instance, there were hundreds of wells in the country which were unworkable by any pump other than the air-lift type, owing to the presence of sand. The air-lift type of pump had also many advantages for developing work. The speaker could refer Mr. Purchas to a number of installations in which the ordinary pump gave no yield from the bore, but in which, after the air-lift pump had been tried, using special precautions, considerable yields had been developed.

Mr. Norman Swinden was interested in the paper since he had occasion, some years ago, to study the theory set forth, in connection with mechanical work, wherein, in certain ways, the air-lift pump possessed greater advantages than when used for pumping water. He would instance the pumping of corrosive or acid liquid; there, a ¼-in. pump and a 2-in. pipe would do the pumping work more easily and cheaply than the clumsy contrivance known as the "acid egg," with efficiencies of 3½ per cent. to 7 per cent. Again, some years ago he had been engaged in the development of the electrolytic cell, and had applied the air-lift principle to the pumping and circulation of molten lead, in the form of sodium red alloy, at a temperature of about 350 deg. C. All sorts of pumps had been tried, but, as the temperature of the metal was only a few degrees above its solidifying point, as soon as the plunger of the ordinary type of pump had started up the tube the metal began to freeze, and stopped the whole operation. The air-lift pump was then applied, experimentally, and proved successful, continuing so ever since. The use of air lift with hot bodies enormously increased efficiency. In pumping gas into a chamber containing a liquid at, say, 400 deg. C., the volume would be very greatly increased, and in pumping the alloy to which he had referred by means of an air-lift pump great success had been achieved; no other pump would meet the conditions. Another use for the air-lift pump was in connection with the circulation of liquids in chemical operations, where oxidation occurred simultaneously. He would take a case likely to arouse much interest in the future, *i.e.*, that of salts of nitrogen vapour. Here the air-lift pump would not only circulate the liquid but would oxidise it at the same time, performing a double function. As to the general theory, he had evolved a theory closely approximating to that of the author. He regarded the air-lift as a U-tube, with one leg longer than the other. Equilibrium could be produced by aerating one leg to an extent equivalent to the pressure in the other, motion being imparted merely by friction. He had found that by assuming practical figures for friction he obtained theoretical efficiencies up to 80 per cent. and 90 per cent.

Mr. Druitt Halpin asked for information as to the indicated horse-power of the engine used by the author in his experiments. In Table I the indicated horse-power for the compressor cylinder was given, as well as that for the energy of the air leaving the foot-piece. The efficiencies of both engine and compressor might be very variable quantities, and the value of the paper would be enhanced by knowledge of the indicated horse-power of the engine. He wished to advert also to the great capital saving effected by the use of air-lift pumps. Going back 30 years, he recalled a case in which, while it was essential that water supply should be continuous, there was no available room for emergency storage to meet chance breakdowns or the natural repairs that would be required. He had been obliged to resort to the costly expedient of putting down two wells, each 600 ft. deep. Some five years later, when air-lift pumps were beginning to be taken up, he went into the question, and found it possible, by an air-lift installation, to save the capital cost of one well, two compressors and other duplications being employed at the surface. So far as he knew, nothing had since gone wrong with the pumping.

Mr. Percy Griffith remarked that he had himself dealt with the subject under discussion in a paper, not from the theoretical and scientific aspect considered by the author, but from a commercial standpoint. There was, however, a distinct need nowadays for bringing the two points of view nearer to each other. Attention had already been directed in the discussion, to considerations other than economic affecting the large demand for air-lift plant in this country; indeed, the speaker believed that it cost three times as much to pump water with air-lift than with the ordinary economical form of pump, and he had not heard it suggested that the air-lift system should be applied where any other form of pump could be conveniently and economically employed. Air-lift pumping had, however, so many applications to special circumstances that more should be known of its actual and theoretical working, so that definite information might be available. In this relation, he desired to direct attention to the fact that the Institution of Water Engineers would discuss the subject on December 7 next, and he urged the advantage of the Institution of Mechanical Engineers arranging a joint meeting; in any event members interested would be welcome at the meeting to be held by the Water Engineers. He concluded with a plea for adequate research to be made into the subject, with a view to the production of an air-lift apparatus which could be applied under more economical and favourable conditions than at present.

Mr. Munro remarked that the author had claimed an efficiency of 80 per cent. or 90 per cent. for the air-lift pump, and in Table I had set out the efficiency of the eduction pipe as the equivalent in work done in horse-power divided by the energy of the air leaving the foot-piece, the figures submitted being 61 per cent. to 62 per cent., much below 80 per cent. or 90 per cent. Comparing the air-lift itself with the ordinary deep-well pump, and leaving out of account the steam cylinder, comparable with the compressor, the efficiency of the other parts of the deep well apparatus amounted to 90 per cent. or 92 per cent., which showed a large margin in favour of the deep well pumping engine. The author had said nothing about coal consumption, whereas in most tests some idea of the coal consumption per P.H.P. per hour was given, and the cost of pumping could be estimated. The author had also stated that current practice favoured greater ratios of submergence to lift the lower the lift, and he (Mr. Munro) would inquire whether this reduction of ratio was voluntarily or com-

pulsory on the part of air-lift pump constructors. Deep submergence was impracticable with deep lifts; when the pipe reached the bottom it would go no further.

Mr. Edward Batten narrated, as an instance of commercial courage and enterprise, an experience, dating back some years, in which a large quantity of water was required for evaporative condensers. The quality of the water was of little consequence. A firm of engineers who had specialised in this work offered to find the water and to take over the plant, charging, per 1,000 gallons, the rate asked by the waterworks people. They agreed, further, to pay for the fuel used in running the plant, and to turn over the plant to the original owners at the end of five years, free of cost. The proposal was accepted and the scheme carried out, the plant was returned at the end of the five years, with complete satisfaction to all parties to the contract,

Mr. H. F. Rutter regarded the question of corrosion of the internal surface of the eduction pipe as one of great importance. With continued use of such pipes the coefficient of friction rapidly increased, and the prevention of corrosion of steel in contact with water was a problem calling loudly for solution. No coating so far tried was entirely satisfactory. Possibly the remedy would be in the use of some unoxidisable alloy of iron, or possibly the application of some substances which would combine chemically with the surface of the steel, and so prevent corrosion, might be hoped for; experiment had progressed in the latter direction.

Mr. W. H. Patchell, the next speaker, had found that engineers were driven to the air-lift pump on account of the repairs involved in the use of deep-well pumps and the capital cost of putting down new pumps. The first deep-well pumps he had dealt with were placed in a 6-ft. well something like 130 ft. or 140 ft. deep, with a bore hole at the bottom of it. Two pumps were in the well, and they gave considerable trouble. Getting down to them was a long and not easy job. He therefore put down air-lift pumps in other works, all the moving parts and machinery being on the surface. The well gave no trouble, although, after some years working, the air-pipe had to be renewed. The previous speaker was in error in supposing that corrosion of steel was produced by contact with water; it was contact with air and water that set up the trouble; immersion in air or immersion in water did not matter, but mischief arose with alternate wetting and drying. Therefore it was only necessary to pull out and repair the pipes, and the considerations of cost and time were unimportant. As to efficiency, the speaker had always maintained that, compared with a well-made plunger pump, with good gearing, the efficiency of the air-lift type would scarcely bear speaking of; but the overall, commercial efficiency of the latter pump was far and away better. This, however, might not apply if power current were purchased at too high rates.

Mr. E. L. Burne observed that the difficulty of determining the efficiency of the air-lift pump beforehand was another circumstance additional to low efficiency militating against its adoption. If any guarantee, for instance, were given for raising a definite quantity of water a large margin had to be allowed in relation to the compressor. On the question of arranging the two pipes in the nozzle in such a manner as to get definite results, it appeared to him that this should be a simple thing to effect; frequently, however this was not the case. The speaker regarded the type of foot-piece shown in Fig. 3 of the paper as a step in the right direction, and took the view that too much attention had been given to certain particular types of foot-piece. On the subject of avoiding corrosion in the pipes, he suggested the use of copper, although, in long lengths, difficulties might arise, especially with the screw threads; at all events, the lower portions might be of copper. He thought the author's displacement theory met the facts, and possibly explained pulsating delivery. He would expect, from the "flotation" theory, as he would call it, a more or less regular delivery of water, but his experience with air-lift pumps did not confirm this. Nevertheless, as practically continuous discharge of emulsion had been observed (tests 6, 7 and 8 in the D series), he would assume that the "flotation" theory was realisable under certain conditions. If the displacement theory were correct, it emphasised the importance of reducing friction in the eduction pipe; otherwise displacement would take place outside. Moreover, the theory furnished a reason for enlarging the eduction pipe as the top was approached. The author's plan of increasing the size of the eduction pipe by stages was doubtless the best practical expedient.

The President asked the author for further information on the theory of the pump. The object of the paper, he presumed, had been to try and illustrate the theory of air-lift pumps, and to give one or two experiments on which an attempt to determine the constants could be based. Two theories were given for determining the two equations, *i.e.*, the relation between volume of air used at atmospheric pressure and the volume of water pumped out. The methods differed totally: which was right? The author assumed Vm to represent the volume of air in the eduction pipe, at some mean pressure, the volume of the water being given as Vn, and had then proceeded to state that because Vn was the volume of water pumped Vm would be the volume of air required per minute. There was, however, no necessary relationship between the two. To the speaker the ratio between the air and water in the eduction pipe at any moment was not the same thing as the ratio of air to water discharge, which, he thought, would depend upon the shape of the eduction pipe. There might, however, be some explanation of this apparent flaw in the argument. Turning to Fig. 8 of the paper, representing the conditions after a single bubble of air had been injected, the author had stated that the weight of the bubble was negligible when compared with an equal volume of liquid, and the bottom of the eduction pipe being open, the pressure on the two sides of the plane X—X would remain balanced; therefore there must remain in the eduction pipe after the injection of air the same volume of liquid as before, and the height of the liquid in the eduction pipe must accordingly be raised. The speaker contended that that would only be true if the bubble filled the whole of the pipe, the difference in pressure between the two sides of the plane depending entirely upon the head of water. Whether or not the bubble was put in the middle of the column would not in the least alter the head of water. Some explanation seemed to be needed. In a general idea of the pumps in question, the important considerations were, if the well were large enough, to get a good bell-mouth entrance, to divide up the air jets considerably and obtain a low velocity.

Mr. Purchas then replied to the discussion, leaving for a written communication points demanding special consideration. Mr. Dolby had asked for definition of terms, but the speaker had referred in the paper to the lamentable lack of some standard for making and recording the tests, and he had employed those names which he regarded as the best. Co-operation to secure the suggested standard was highly desirable; it was annoying when attempting comparison of tests published by different people, to find that the results were recorded in different ways and the terms had different meanings. The differential pressure gauge he had used was a home-made instrument. A start was made with a plain U-tube, but it was found that for small differences no readings were obtainable. The actual readings could, however, be magnified by 10 when the tube was made into a V-tube, with a grade of 10 : 1. Gradually he had developed an instrument which could be bent, by means of swivel joints, into a form which was practically horizontal; graduated scales were put on, and a very simple gauge was produced in that way. Referring to the objections raised to his records of volumetric efficiency of the compressor from the cards, he would explain that in tests Series A he had no means of measuring the air actually used; in the later tests he had. Therefore in the A tests the volume used, measured at the temperature of the liquid, had to be assumed, and as some guide he had had put in, for comparison, the values taken from the cards, showing that piston leakage and other matters were somewhat the same. He had also wished to demonstrate that the 95 per cent. repeatedly given as the volumetric efficiency of the compressor, upon which the volume of air used was based, did not compare with the realised figures, which, in the case of the plant under discussion, was nearly 70 per cent. Objection had been raised to two of the considerations upon which he had based the volumetric efficiency of the compressor. He had included the two items for the reasons above explained. In estimating the volumetric efficiency for Series A only he had taken the known condition of the valves and guides, and also of the cooling jacket, into account, because he believed they had a distinct bearing on the matter. He had taken his coefficients for the calculation of flow through the orifice from the paper contributed to vol. xxvii of the Proceedings of the American Society of Mechanical Engineers, in which a full description of volumetric tests of displacement tanks, with varying sizes of orifice and at varying rates of flow, was given. The orifice had a dead sharp edge in a plate of given thickness. With regard to the parabolic orifice, he would ask whether it could be inserted in a pipe. [Mr. Reavell here stated that it had been so used.] Mr. Purchas, continuing, remarked that an orifice of that type would be of great advantage in endeavours to test air-lift pumps, the calculations based upon the use of other types being long and tedious. By the phrase "best compressor" he had meant the compressor which would deliver a given volume of air for the least energy; he agreed that, in this connection, he should have used the term "weight." When stating that air-lift pumping had fallen into disrepute, he had added the words "with many," and he referred more particularly to engineers who were not specially interested in that class of work. With regard to the foot-piece he admitted that the clogging of the air pipe was a serious fault, and, as a result, after a few months running, it became necessary to put on an additional air pressure of 30 lb. to the square inch, and eventually the foot-piece had to be removed because no air could be got through. He would like to point out that the tests made were progressive from year to year, and the displacement theory had therefore been gradually evolved from experience. In regard to the opinion that commercial efficiencies should always be stated, he agreed, but he must lay the blame for lack of development of the air-lift pump on the fact that only commercial efficiencies were stated; the use of cheap compressors of low efficiency was frequently responsible for the ill repute in which air-lift installations were held. In his paper he had endeavoured more particularly to bring forward the theoretical as distinct from the commercial aspect of air-lift pumping, and it was for this reason that he had not raised the question of merits. The interesting application by Mr. Swindon of the air-lift system to the pumping of hot liquids was the first of the kind that he had heard of. As another instance of the exceptional use of air lift, he would mention its substitution for a suction dredger, water and sand being discharged from the bed of a lake. In reply to Mr. Druitt Halpin, he would point out that the tests were made with a view to getting results from the working of the air-lift pump itself, and for that reason the indicated horse-power was omitted from the test records. He would, however, endeavour to look up the information desired. He could not in the least agree with the statement that air-lift pumping was three times as costly as any other. On the practical side he had been interested only in installing air-lift plant for firms he had been engaged with; but he was convinced, in the case of the plant tested, that the pump would prove more economical than any other pump. As to the claim he had made for a possible efficiency of 80 per cent. for the air-lift plant, he would point out that the figures actually recorded showed 62 per cent., and in speaking of the method of designing he had assumed an efficiency of 70 per cent., beyond which he was not at present prepared to go; this figure of 70 per cent. was, moreover, supported by the curve shown in the diagrams. In an earlier paper which the speaker had written, he had referred to the question of cost of plant raised in the present discussion. The plant in that case was worked with oil fuel to begin with and, later, natural gas.

The cost figure would hardly be of interest, because the plant was located in an oilfield and because labour costs were high, involving a great deal of automatic control in the way of burners, feed water, &c. As he had said, he was chiefly concerned, in the case of the tests recorded in the paper, with the air-lift pump operation. A question had been asked as to whether the ratio of submersion was voluntary or compulsory, and he could only say that in discussing the point with engineering firms they agreed upon this ratio, although in many cases it might be forced upon them owing to the depth of the well. Nevertheless, many preferred a higher ratio of submergence for low lifts than for high ones. The subject of corrosion was a large one in itself, and in the course of his tests corrosion was a constant trouble. In connection with the diagram, Fig. 9, of the paper, the eduction pipe used in that test was badly corroded; notwithstanding the efficiency, curiously enough, was not less than in the case of a clean pipe. Corrosion difficulties occurred both in the lift and in the wells. It might interest Mr. Rutter to know, if he were not already aware of it, that the Western Australian Government had issued a bulletin dealing with corrosion, and the speaker had, in fact, availed himself of some of the suggestions made therein, such as passing the water through a vacuum tank. As to the suggestion that the lower portions of the eduction pipe should be of copper, he might say that the corrosion was equally bad at the foot and the top; apparently, it was uniform from top to bottom, for which reason the use of copper at the bottom would help matters little.

The president then announced that Mr. Purchas' paper would be read again in Leeds at an early date. Further, that the Thomas Hawksley lecture, on "Heat Engines," would be delivered by Captain H. Riall Sankey in the Hall of the Institution of Civil Engineers, on the 30th inst., at 6 p.m. Every effort would, the president said, be made to comply with the request from provincial places that the lecture should be delivered there. He concluded the proceedings with the further announcement that the next ordinary general meeting of the Institution would be held at 6 p.m. on Friday, December 14, next.

THE LATE MR. PETER DENNY.

MANY will share our regret at the announcement of the death, from heart failure, at his residence, Crosslet House, Dumbarton, on the 19th inst., of Mr. Peter Denny, a member of a family which has done much work to establish shipping and marine engineering on a truly scientific basis. In this work Mr. Peter Denny took an effective part. At the same time he fulfilled in a marked degree those varied duties of an employer of labour connected particularly with the social life of the worker. Indeed, in this respect he, like his relatives, has shown an example worthy of imitation by other leaders of industry.

Mr. Denny was the second son of the late Mr. Peter Denny, LL.D., long the head of the Dumbarton firm, and was born on June 30, 1853, being thus in his sixty-fifth year. He served an apprenticeship of five years in marine engineering in Messrs. Denny and Co.'s works at Dumbarton, passing through all the departments. He added to his experience by being for a short time an engineer on board ship. On his return he was appointed to the managerial staff, becoming, in 1879, a partner in the firm. Four years later, he joined the firm of Messrs. William Denny and Brothers, shipbuilders, along with his brother, Sir Archibald Denny, Bart., Colonel Denny, another brother, having been admitted to the partnership in 1881. From this time onward he was a coadjutor with his seniors in the firm, and his sound judgment and practical experience were important factors in the success of the progressive policy which characterised the constructional work of both firms. It is well known that, first, the firm led the way in the design of ships, in many important evolutions. Secondly, in marine engineering their paddle-wheel machinery resulted in a great advance in speed, as was evidenced particularly by the vessels built for the Belgian Government and trading between Dover and Ostend; later, similar progress was made with twin-screw steamers, first with high-speed reciprocating engines and later with turbines. In the construction of all this machinery and in the trials, Mr. Peter Denny showed active enthusiasm, and in this way inspired all under him.

The subject of our memoir joined the Institution of Naval Architects in 1880, but took little part in their proceedings. In connection with the foremen's organisation in Glasgow, however, he found an outlet for his desire to promote professional interests. In Dumbarton corporate and social life he took a full share of employers's responsibilitity. He served for some years on the Town Council and in the magistracy. he was also on the County Council, was a justice of the peace for the county and honorary sheriff substitute in Dumbarton; on the bench he displayed a surprising knowledge of the law for a layman. He was one of the founders of the Dumbarton School of Science and Art, and took a prominent part in it. He was active in all agencies, having been President of the Philosophical Society, Choral Union, and of most of the athletic clubs. He was associated with Mr. Douglas White, of Overtoun, in presenting a children's park and playground to the town. In this and other ways he exercised great influence, which was enhanced by his kindly disposition and gentle nature, being ever ready in sympathy and benevolence. Since the war broke out he had wider opportunities for the operation of these distinctive characteristics, and in all this work was greatly assisted by his wife, with whom much sympathy is felt.

THE LATE MR. ALEXANDER ADAMSON.

WE regret to learn of the death, at his residence, St. Andrew's, Chislehurst, of Mr. Alexander Adamson, who, in the 'seventies and 'eighties, took a prominent part in the evolution of the modern Atlantic liner, and was later identified with the early stages of development of the Barrow works, now the most important naval armament and munition works in the kingdom. Although Mr. Adamson retired from the shipbuilding business about seventeen years ago, he took some part in the shipping business of his sons.

Mr. Adamson was born in Glasgow on October 29, 1846, and was thus in his seventy-second year. He was educated at the school in Carlton-place conducted by the late Mr. John Mayer, where many of the shipbuilders and engineers of the past generation got their first training in technical subjects. He served his apprenticeship at the engineering works of Messrs. Randolph, Elder and Co., from 1861, the firm having, in the previous year, commenced shipbuilding in the present Fairfield yard. Mr. Adamson received a thorough training, both in practical work and design, and when Sir William Pierce joined the firm in 1869 Mr. Adamson was appointed chief draughtsman in the shipbuilding drawing office. From this date onwards, until 1883, he was closely identified with the successive Fairfield-built Atlantic liners which won the name of "Greyhounds of the Atlantic." He was appointed shipyard manager in Palmer's Jarrow works in 1883 and, later, entered the employment of Messrs. Armstrong, Mitchell and Co. at their Low Walker yard, on the Tyne. There he continued until the late Mr. Bryce-Douglas took over the managing directorship of the Barrow works, formed in 1871, and reconstructed, in 1888, under the title of "The Naval Construction and Armament Company, Limited," with the late Duke of Devonshire as chairman and Mr. Bryce-Douglas as managing director. The last-named engineer had been at Fairfield when Mr. Adamson was there, so that there was complete sympathy between them. Their association at Barrow, however, did not last long, as Mr. Bryce-Douglas died in 1891, and Mr. Adamson succeeded him as managing director. The passing of the "Naval Defence Act" and the formulation of a programme of naval construction extending over a considerable period, was coincident with Mr. Adamson's appointment to the Barrow works, and he and his co-directors, by their enterprise in works development, greatly assisted the Government in carrying through their extensive programme. Thus, during the twelve years that Mr. Adamson was at Barrow, there was constructed a succession of warships of every type, as well as a large number of merchantmen, the total number of vessel of all types launched during his *regime* being 117. The Vickers Company took over the works in 1897, and Mr. Adamson retired in April, 1900.

Mr. Adamson had a remarkable grasp of details in design, and was thoroughly practical in his work. He was a most painstaking worker. Although a J.P. of Barrow he took no part in public life, devoting all his time to the advancement of the establishment. He was elected a member of the Institution of Naval Architects in 1882, and served for some years on the council, from 1898. He is survived by his wife and a grown-up family, with whom there is much sympathy.

PERSONAL.—Mr. Leonard Harrold, of 57, Gracechurch-street, London, E.C.3, has been appointed representative for London and the district of Messrs. M. and G. Beaumont, of Briar-street, Nottingham; of Messrs. Mountford, Phillips and Co., Limited, Brierley-hill, Staffordshire; and of Messrs. T. Toward and Co., Limited, Newcastle-on-Tyne.

INDUSTRIAL NOTES.

THE Director of the Department of Labour Statistics, dealing with the labour market, states in *The Labour Gazette*, that nearly all the principal industries were fully employed in October, and in many cases much overtime was worked. In the cotton, woollen and worsted trades, however, employment was affected by the current orders restricting consumption.

The changes in rates of wages (including war bonuses) reported in October affected nearly 600,000 workpeople, and resulted in a total increase of over 130,000*l.* per week.

The principal changes reported were the bonus of 12½ per cent. granted to skilled engineers and iron-founders employed at time rates on munitions work, and the further increases to woollen and worsted operatives in Yorkshire, by which the wages of piece-workers in the weaving branch were raised to 48 per cent. or 51 per cent. above pre-war rates, and those of other operatives to 60 per cent. above pre-war rates.

The number of disputes beginning in October was 69, and the total number of workpeople involved in all disputes in progress was 86,417, as compared with 77,767 in the previous month and 18,697 in October, 1916. The estimated total aggregate duration of all disputes during the month was 568,200 days, as compared with 705,100 days in September, 1917, and 106,600 days in October, 1916.

The average weekly number of vacancies notified to all Employment Exchanges for the five weeks ending October 12, 1917, was 38,097, as compared with 38,133 in the previous four weeks and with 40,005 in the five weeks ending October 13, 1916. The average weekly number of vacancies filled for the same periods was 28,477, 29,363 and 30,413 respectively.

The Ministry of Labour forwards the following for publication:—

The Building Trades Central Advisory Committee (Operatives) which advises and assists the Ministry of Labour on matters affecting workpeople in that industry, which arise in the administration of the Employment Exchanges, held their eighth meeting on Wednesday, the 14th inst. The committee discussed, among other subjects, the arrangements for setting up an Advisory Committee in connection with the proposed Central Employment Exchange for the building trades in London. They also considered the question whether the Employment Exchanges, in submitting men for vacancies notified by employers, should give a preference, other things being equal, to discharged sailors or soldiers. On this point the committee agreed to advise the department that, in their opinion, it would be inadvisable to depart from the existing procedure under which purely industrial considerations are taken into account.

A Women's Trade Union Advisory Committee, consisting of representatives of the trade unions which comprise women members, has been formed at the request of the Ministry of Munitions. The committee is analogous to the committee set up by Mr. Churchill some months ago to advise on matters concerning men's work, and it is proposed to refer to it all questions affecting the employment of women on the production of munitions. It is to be understood, however, that the work of the new committee will not overlap that already done by the Women's Wages Tribunal.

Mr. Churchill, at the first meeting of the committee, explained its constitution and procedure, and emphasised the fact that the Ministry of Munitions strongly realised the importance of its work in regard to the employment of women. "We are," he said, "incomparably the greatest employers of women there has ever been in the world; in fact, we are the pioneers of women employment in the industrial and even in the military field. Whatever may be the future position which women labour will take after the war, it will be enormously influenced by the actual practice which has been followed during this period when so much is in the making, and when so much control is vested in the organisation of the Ministry of Munitions."

"The relation of woman labour to male labour," he added, "is one of the most difficult questions which could be presented, and yet it is a question which requires a fairly simple answer. It is perfectly clear that it would not be in the interests of women to claim a 'cut-and-dried' equality or a rigid equality. That would end in their being very largely excluded from the industrial community. What they want is a comparative equality, an equality which makes full allowance for the necessary differences of sex, strength and requirements of physical well-being, and which assures to both sexes in the industrial community the means of giving the fullest contribution that they can give without injury to health and happiness, to the general welfare of the State, and secure to them in the fairest measure the legitimate share of the rewards of the labour they have contributed.

"No question affecting women's employment,"

Mr. Churchill further stated, "is excluded from the deliberation of this new Advisory Committee. If the committee," he concluded," is able to develop a powerful, penetrating and enlightened view of these subjects I do not see the limits of the usefulness and power which they may come to exert in the near future."

A correspondent writing to *The Glasgow Herald* states that the recent Order issued by the Ministry of Munitions whereby skilled engineers and moulders, paid strictly by time rates, must receive a bonus of 12½ per cent. on their earnings, has had the effect to create grievances and to multiply difficulties in the industrial world on the Clyde.

In the Clyde area, the Order has given rise to a series of intricate problems as to the nature of certain bonuses, and the settlement of these, unless some special machinery is set up, will require a long period of time, during which the various workers affected will labour under a feeling of injustice and will be irked by the delay. The solution of the difficulties within the Order itself must be speedily found, and to this end a special local wages tribunal might be constituted.

This, however, will only touch the fringe of the question in so far as it leaves unaltered the position of the numerous aggrieved workers who are at present excluded from benefit, and fails to take cognisance of the inhibiting influence of the award upon the extension of payment by results. It may as well be confessed that the only feasible plan seems to be either to withdraw the Order or make it quite general in its scope. Withdrawal would now probably prove impracticable —it would be too much to expect the men who have gained to make the necessary sacrifice—and the conversion into a universal advance to munition workers has the merit of at once abolishing the particular difficulties which already have become apparent and quieting the general feeling of unrest. The failure at the time of issue to appreciate the influence of the document may be regretted, and the necessity to extend its cope because of its effect upon the mind of labour may be deplored, but the price is worth paying, if disquiet and disaffection can be prevented at the present juncture. Of course, such an extension will leave unsolved the inequalities between skilled men on time and diluted labour on piece in certain establishments, but these are not beyond repair, and experience will surely teach another method than a vaguely worded Order.

The Cabinet have agreed to the 12½ per cent. bonus being paid to all time-workers employed on munitions and shipbuilding.

Mr. W. W. Wood, junr., Wardsend Steel Works, Sheffield, in an address which he recently gave to a meeting of Ecclesall conservatives, dealt with British and German trade. He said that the question of Fair Trade, or Tariff Reform, should not be treated as one of politics. He believed there were some firms who had benefited by the importation of cheap German goods, but there were other firms who had not benefited. He could give them his own experience in regard to one of his own products, namely, wire rods. Of these his firm manufactured some thousands of tons per year, and they were largely used for Admiralty and other Government purposes. When the war broke out in 1914, German rods were pouring into this country in larger quantities than ever, at a price which brought down the selling price of English rods to such a figure that it left practically no profit, and in some cases caused a dead loss. The system consisted in the main of erecting large plants in Germany capable of turning out much more than was needed for home requirements, and then dumping the surplus, which in this case amounted to about 100,000 tons per annum, into this country, the total transaction showing a satisfactory profit. One of the most annoying features about this dumping was that goods were carried from the Continent to Sheffield for less than the home manufacturer could send goods from Sheffield to Birmingham. In view of this, it was not surprising that manufacturers hesitated about spending money on new works, and that they were not always able to pay such wages to their workpeople as they would have wished. He did not think that the whole question of Tariff Reform could be dealt with from the point of view of any one or even of any dozen firms, but the point to be considered was as to which method would make for the greatest good of the nation, and this could only be arrived at by taking a consensus of opinion on the subject. As regarded the particular trade he had named, if the same state of things had gone on, the Germans would have absolutely beaten this country within fifteen years. On the other hand, if German goods were kept out after the war, every workman engaged in the wire trade would be assured of full time and good pay. He did not believe in going baldheaded for or against a subject simply because one side or the other might adopt it, or simply because it might or might not benefit one particular section of the community. But he could not conceive of any Government in its senses not only allowing but requesting manufacturers to put down plant and spend large sums of money to meet the demand for goods which previously came in from abroad, and then consenting to the same state of things being resumed which prevailed before the war.

Official statistics have now been issued dealing with strikes and lock-outs in Denmark during the first five years (1911–15) the Mediation Bureau has been in existence. The number of labour disputes in this period amounted to 274, or an average of 55 per year; 22,500 hands went out on strike and 25,000 were locked out, of which latter figure nine-tenths fall to the year 1911. The number of operatives covered amounted to about 150,000. The number of working days lost aggregated 1,164,000, which represented a total of over 4,000,000 kronen lost in wages. The employers' loss through the disputes cannot adequately be made up. Among the labour conflicts, 75 ended in favour of the employers, 93 in favour of the operatives, whilst 85 ended in a compromise, and in the case of 21 the settlement was indefinite. During the five years covered by the statistics, 32 disputes were settled by the mediation of the State arbitrator, whose timely intervention is acknowledged to have prevented other labour disputes from coming to a crisis.

We have received from the Secretary of the General Federation of Trade Unions an advance proof of his latest report, in which the following is stated :—

During the past three years the federation has interpreted the situation and the solid mass of public opinion more accurately than any other Labour organisation, and it has made fewer mistakes. When war broke out it appealed for national solidarity, and the considerate treatment of soldiers and their dependants. It pointed out that the controlling of prices and the organising of distribution was of more importance than increasing nominal wages, because the two former factors affected all the people, while the latter only affected sections of them, and these even did not benefit commensurately.

Early in 1915 it proposed to the Board of Trade that the sale of ships both within and without the British Register should be stopped, and that all internal transit, including ships, canals and railways, machinery and appliances, should be pooled and used for the common good. Had there been adequate support from all other labour organisations more rapid progress and better results might have been achieved.

The federation opposed the Stockholm and Berne Conferences because, having experience and being without political ambitions, it was able to foresee the futility of gatherings, the component parts of which had reached no clear idea of what was wanted or what was possible, and who would necessarily be antagonistic. Every day had brought new justification for its attitude and new condemnation of those who, lacking knowledge of the mentalities of peoples in other countries, had presumed to advise and guide. The General Federation of Trade Unions warned its members, and through them other people, of the danger which would follow any imitation of the impracticability which had endangered the Russian revolution, and it insisted upon the need of affording British industry the fullest post-war opportunities for readjustment and expansion. It had insisted also that in any peace settlement the colonies and dependencies who have fought shall also negotiate.

As far back as July, 1916, it issued an international Labour charter, which has been copied or reproduced in many countries.

Because the federation has done these things it is called reactionary. It is quite content to be judged by its record. It only asks that its record may be considered.

Financially the federation was stronger now than at any period during its existence. There had been a slight increase in the number of disputes for which benefit had been claimed, but these had been of short duration, and over 12,000*l.* had been carried to reserve.

In the course of his presidential address, delivered last Saturday before the Cleveland Institution of Engineers, Middlesbrough, Mr. J. H. Harrison, M.Inst.C.E., M.Inst.M.E., mentioned the progress which the Tees-side iron, steel and shipbuilding trades had made, and stated that all the evidences shown of increasing activity and of productive power were clear proof of a great awakening to the fact that the Tees-side district was by far the most important district in the whole country for the production of iron and steel. The work the Tees Conservancy Commissioners had done and were doing for the benefit of the district was not fully appreciated. The Commissioners had converted a straggling stream into a mighty river, and had continually and successfully induced industrial concerns to settle down on the banks of the Tees. The Ministry of Munitions had "discovered" Middlesbrough, and had put a value upon it which ought not only to be kept hold of, but continually increased. Middlesbrough had been too modest, and had been satisfied too easily with the production of the raw material upon which the greatness of the nation was built, and which was even now, in Flanders, enabling its greatness to be felt throughout the world. Middlesbrough and district was destined to become recognised as one of the greatest capital assets in the country. The corporate bodies who managed the town and district would have to take a broad and bold view of what was coming, and prepare, from a national, as well as from a local point of view, to keep in front of the requirements of what was to be a vast manufacturing centre.

At a recent conference of the American Electric Railway Association in New York, two aspects of the labour situation were presented in two papers, the one discussing the possibility of the wider use of women in railway service, and the other the question of the so-called war bonus for employees. The author's views on the latter subject, says *Electric Railway Journal*, New York, were, briefly, first that labour would be scarce for a number of years after the war and, secondly, that with conditions as they were at present railways could not afford to pay a war bonus. In these circumstances, the two alternatives were the more extended use of female labour and the use of less platform labour.

The thought was expressed by several managers, both before and after the meeting, that women could serve in many more positions than they now did in electric railway operation.

Women, adds the American journal, had long been extensively employed in railway shops, in the manufacture of coils and in armature repairs; but the experience abroad in ammunition work showed a much wider range of opportunity in the shops than this. Thus, in Europe, women had shown their ability to operate machine tools, and in such work their delicacy of touch and pride in their work gave them advantages over men. All-in-all, there seemed to be no reason why they could not be employed to a greater extent in electric railway repair shops than at present.

It was, however, on the platform that the largest field was open, because of the large percentage which platform labour bore to all labour employed on an electric railway. As far as conductors were concerned, much of the supposed prejudice on the part of the public in this sphere would be found not to exist on actual trial.

The final result of the ballot of the South Wales miners on the issue of the adoption of a "down-tools" policy in connection with the military "comb-out" has now been officially declared as follows :—

For the "comb-out"	98,946
Against	28,903

or a majority for the "comb-out" of 70,043.

The result is generally and rightly regarded as a rout of the pacifist element. It is acknowledged on all hands that it would have been still more decisive but for the attitude of considerable numbers of the men, including one whole district—that of Risca, in Monmouthshire—who declined to have anything to do with the ballot on the ground that they were determined to go on working whatever might have been the upshot. It was also unfortunate that the examiners' strike synchronised with the dates for taking the ballot, and this coincidence helped the malcontents very appreciably. It is also noteworthy that in almost every case the pacifist leaders failed to secure an affirmative majority even in their own lodges.

As the result of a referendum to the members of the South Wales Colliery Examiners' Association, who recently came out on strike, an agreement has at last been reached in connection with the men's demand for recognition. The coal owners having modified their proposals, these were referred to the members of the association, and a conference vote was taken this week which resulted as follows :—

For accepting the terms	3,339
Against acceptance	280

Or a majority for acceptance of 3,059.

The dispute may, therefore, now be regarded as settled.

THE HEROULT ELECTRIC STEEL FURNACE.—Licenses for the installation of nine Héroult electric steel furnaces have been granted by the United States Steel Corporation, says *The Iron Age*, to three private firms and to the Watertown Arsenal. The erection of these nine furnaces brings to 144 the total operating or contracted for in the United States and Canada.

SOME NOTES ON AIR-LIFT PUMPS.*

By A. W. Purchas, of Wolverhampton, Associate Member.

The subject of air-lift pumping has not received the attention it deserves from engineers, and has fallen into disrepute with many. There are several good reasons for this, among which may be mentioned the lack of a satisfactory theory, the low efficiency of most installations, and the lack of complete and accurate reports of tests, so that the causes of the low efficiency are obscured.

An attempt is made in this paper to rectify the first, to show how the second can be improved, and to point out in what respects many reports of tests are lacking in information essential to a thorough analysis for checking theoretical formulæ and deductions.

An account is given of several series of tests, with a description of the methods and the equipment. The theory of the pump is then reviewed, and a novel method of approaching the subject is given, from which it should be possible to evolve rational formulæ for designing. Throughout the paper many references are given, which it is hoped will add to its value.

Equipment and Methods Employed in Making the Tests of Series A, B, C and D.

General.—The wells on which these tests were made form part of a water-supply system, of which an account was presented to the Institution of Civil Engineers.† Series A of tests was given at that time, but further investigation showed that the author had wrongly calculated the actual volume of air used, and the average velocities of the rising mixtures in the eduction pipe. By their kind permission, it is possible to reproduce these test figures with the errors corrected, and other valuable deductions added.

On pulling the eduction pipes from the wells, after they had been in operation for some length of time, the interior surfaces were found to be heavily encrusted with nodules of rust, some ½ in. high, of such rugged outline as to leave no trace of smooth contour on the surface of the pipe. The tests of series A are of one eduction pipe when newly installed, and the tests of Series B are of the same pipe when encrusted as described above. A comparison of these two series shows some very interesting points. The eduction pipe used in the tests of Series C was badly encrusted, but that of Series D was clean.

Air-Injection Foot-Pieces.—The foot-pieces used in the various tests are shown :—

For Series A in Fig. 1.
For Series B in Fig. 1a.
For Series C in Figs. 2 and 2a.
For Series D in Fig. 3.

The merits and faults of these are discussed later under the Theory of the Pump.

Lift.—In Series A and B this was measured by lowering a float on the end of a steel-tape line between the eduction pipe and the well-casing. The float was a piece of wood ¼ in. by 1 in. in section, and 6 ft. long, weighted to float upright with about 5 ft. submerged. This method, however, is not recommended, as the float will sometimes become wedged between the pipe couplings.

In Series C. and D the lift was measured with the device shown in Fig. 4. This consists of a piece of heavy brass pipe, inside which a small copper float is free to slide at the least impulse. The whole is suspended by a duplex rubber-covered cable, graduated in feet, one wire of which is connected to the case, and the other terminating in a lump of solder on the lower side of the insulator, which forms the top of the case. At the top of the well an electric bell and batteries completed the installation. The case was lowered into the well, and its reaching the water surface was indicated by the bell at the ground surface ringing. By this means it is possible to measure the depth of the water surface within an inch.

It is absolutely impossible to estimate correctly the lift from the gauge pressure of the air at the well head, and this should never be attempted. Some injection foot-pieces put from 5 lb. to 10 lb. per square inch extra pressure on the air, and there sometimes is a loss of 5 lb. pressure due to friction in the air pipe. A combination of these losses might make an error of 30 ft. in the estimated lift. To estimate the lift from the air pressure required to start the well flowing is equally impossible since, once the well is started, the lift nearly always increases. Reference to tests 1, 2 and 3, of Series D, overleaf, shows that under certain conditions the air pressure at the well-head may be less than that equivalent to the submersion head of the foot-piece. This may be accounted for by noting that a column 600 ft. high of air under 135 lb. per square inch pressure will exert an additional pressure on the base of a column of 3.25 lb. per square inch, due to its weight.

An alternative method of measuring the lift is recorded by Mr. Kenneth Allen in a paper read before the Engineers' Club, of Baltimore, in 1908, on the wells at Atlantic City, U.S.A.

Air Compressor and Measurements of Air Used.—The air compressor is a two-stage, with both air and steam cylinders compounded. The sizes of the more important parts are as follow :—

	In.
Diameter of the air cylinders ...	10 and 18½
,, ,, steam cylinders	12 ,, 22
Stroke of all pistons	18

The air is drawn through a combined forecooler and filter outside and on the shady side of the building, and passes through an intercooler between the two air cylinders. The cooling water is circulated by a double-acting piston pump of 5½ in. bore, and 5 in. stroke, driven direct from the crankshaft of the compressor. The suction valves of the low-pressure cylinder are semi-rotary, and are mechanically opened and closed by an eccentric on the main crankshaft. All other air valves are automatic, spring loaded and air-cushioned.

Many tests, which would otherwise be of the greatest value to the designer, are rendered of only doubtful value because the volume of air used was not carefully measured; hence the average velocities of the rising mixture can only be approximated. These velocities are the most important items affecting the efficiency of the pump, and those on which more than any other, accurate data are required at the present time.

It is found in checking the published figures from too many tests, that the volume of air used was calculated from the known displacement of the low-pressure piston of an air compressor allowing volumetric efficiencies of 95 per cent. and 97 per cent. Considering the types of compressors used, these figures are impossible, and are based on lineal measurements from indicator diagrams on the assumption—unjustified by experiment—that the temperature at the beginning of compression is the same as that of the air at the intake.

The true volumetric efficiency of a compressor based on the ratio of air drawn in at atmospheric pressure and temperature to the displacement of the low-pressure piston will vary :—

	Per Cent.
For single-stage compressors ...	from 50 to 70
,, two-stage compressors ...	,, 60 to 80
,, three or more stage compressors	,, 80 to 95

The above figures are taken at random from various sources, and it is impossible to state average values.*

Returning to the tests here recorded, prior to each series the air valves of the compressor were examined, and their seats put into good condition. On April 25 and 26, 1914, tests were made of the volumetric efficiency of the compressor, and again on May 7 and 8, at the end of each test of the air-lift pump. The discharge from the compressor was measured by means of an orifice, the form of which and the method of connection to the air receiver are shown in Fig. 5. This meter is a duplicate of that used by Professor R. J. Durley, of McGill University, Montreal, to determine the coefficients of the discharge of air through certain forms of orifice. An account of his work is to be found in the Transactions of the American Society of Mechanical Engineers, vol. xxvii.

The formula given in the above paper for calculating the flow through the orifice, is :—

$$Q = 0.6299\ C\ d^2 \sqrt{\frac{i}{T}},$$

in which—

Q is the weight of air passing through the orifice in pounds per second.
C is the coefficient determined by experiment.
d is the diameter of the orifice in inches.
i is the pressure inside the meter-box in inches of water.
T is the absolute temperature F. inside the meter-box.

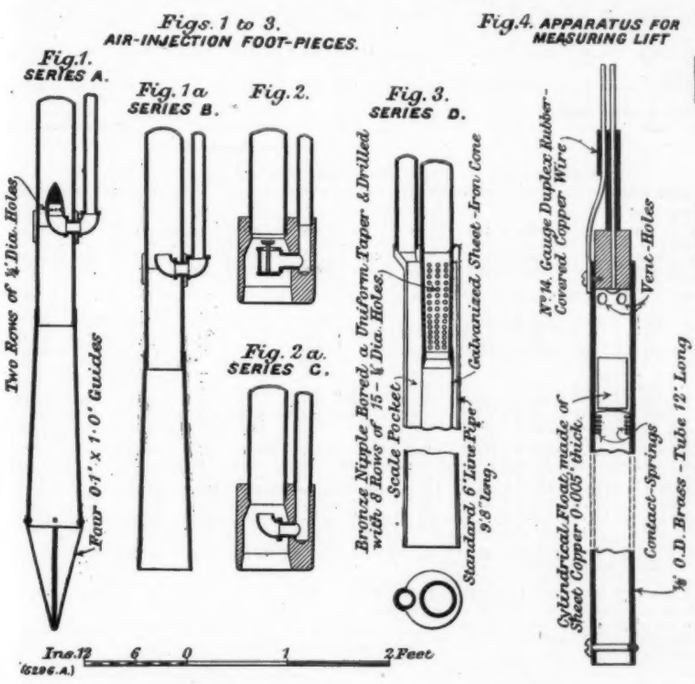
This formula only applies to sea-level, so as the plant at Oilfields is 700 ft. above, the following formula was used to compute the discharge :—

$$Q = 0.1632\ C\ d^2 \sqrt{\frac{i}{T} P_a},$$

in which—

P_a is the absolute pressure in pounds per square inch of the air inside the meter-box. This equals the barometric pressure, plus 0.036 *i*.

For testing air-lift pumps, it is probably more convenient to install a meter in the air line between the compressor and the well. This is more expensive to install, but the volumetric efficiency of a compressor is a very variable quantity, which cannot otherwise be measured during the tests of the well pump. Such a meter is shown in Fig. 6. The principle is identical with the foregoing, and the same coefficients of discharge may be presumed to apply, if the velocity of approach



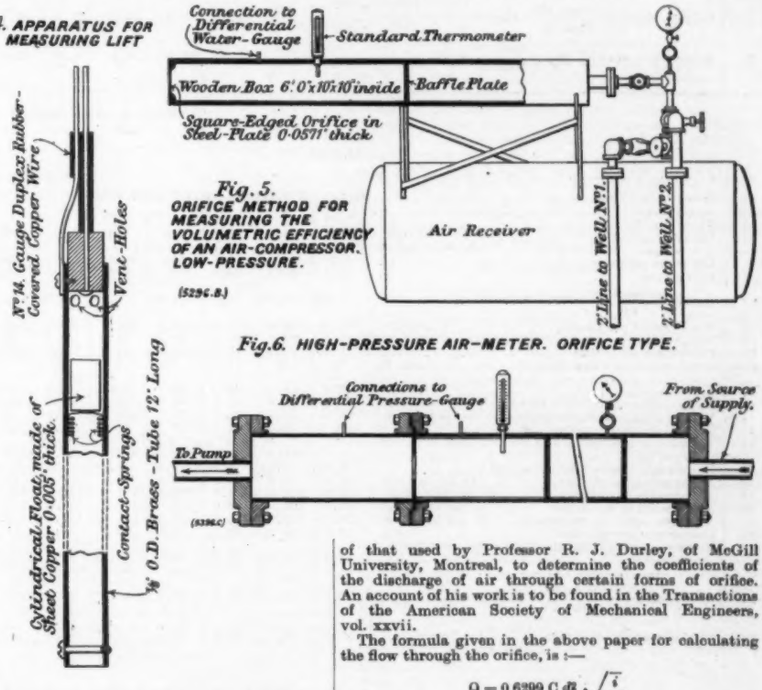


Fig.4. APPARATUS FOR MEASURING LIFT
No 14. Gauge Duplex Rubber-Covered Copper Wire
Vent-Holes
Cylindrical Float, made of Sheet Copper 0·005" thick.
Contact-Springs
⅜ O.D. Brass - Tube 12' Long
Connection to Differential Water-Gauge
Standard Thermometer
Wooden Box 6'·0" x 10" x 10" inside
Baffle Plate
Square-Edged Orifice in Steel-Plate 0·0511" thick
Fig.5.
ORIFICE METHOD FOR MEASURING THE VOLUMETRIC EFFICIENCY OF AN AIR-COMPRESSOR. LOW-PRESSURE.
(5296.B.)
Air Receiver
2" Line to Well No 1.
2" Line to Well No 2.
Fig.6. HIGH-PRESSURE AIR-METER. ORIFICE TYPE.
Connections to Differential Pressure-Gauge
From Source of Supply.
To Pump
(5296.C.)

* Paper read before the Institution of Mechanical Engineers, Friday, November 16, 1917.

† Published in abstract, Proceedings, Inst.C.E., vol. cxciii.

* In this connection, see *Engineering News*, January 16, 1908, where Mr. H. Tipper, of Fort Worth, Texas, stated that he had known of several compressors running with volumetric efficiencies of only 40 per cent., due to poor upkeep of valves, &c. See also Professor Goodman's paper, Inst.C.E., vol. cxxviii.

TABLE I.

		SERIES A.						SERIES B.							
1	Date	23/4/12	17/4/12	18/4/12	19/4/12	22/4/12	12/4/12	18/3/14	18/3/14	18/3/14	19/3/14	19/3/14	19/3/14	20/3/14	20/3/14
2	No. of test	1	2	3	4	5	6	1	2	3	4	5	6	7	8
3	No. of well tested	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	Duration of test, min.	120	120	120	120	120	150	120	120	120	120	120	120	120	120
5	Lift when pumping, ft.	249	257	256	260	262	263	283	283	284	285	286	287	290	292
6	Submersion, ft.	298	290	291	287	285	248	264	264	263	262	261	260	257	255
7	Ratio: $\frac{\text{submersion}}{\text{lift}}$	1.19	1.13	1.13	1.10	1.08	1.08	0.93	0.93	0.93	0.92	0.91	0.91	0.88	0.87
8	Water raised per minute, imp. gal.	138	158	185	188	203	209	66.9	93.1	110.0	120.0	138.0	146.0	160.0	168.0
9	Water raised per minute, cub. ft.	22.1	25.3	29.6	30.0	32.5	33.5	10.7	14.9	17.6	19.1	22.1	23.4	25.5	26.8
10	Equivalent work done, h.p.	10.4	12.3	14.4	15.4	16.1	16.7	5.73	7.98	9.48	10.3	12.0	12.7	14.0	14.8
11	Temperature of water pumped, deg. F.	70	70	70	70	70	70	70	70	70	70	70	70	70	70
12	Air compressor, r.p.m.	30.7	34.4	40.9	46.4	51.5	55.2	20.2	24.8	29.6	34.9	39.8	45.2	55.5	63.6
13	Volume efficiency of air compressor, from cards, per cent.	—	—	—	—	—	—	95.5	95.7	95.5	95.5	95.1	95.1	95.0	94.6
14	Volume efficiency of air compressor, true value, per cent.	70.0	72.0	75.0	75.7	76.4	76.5	68.0	70.0	69.0	70.0	72.0	73.0	75.0	76.0
15	Air in compressor suction pipe, deg. F.	79.6	71.5	64.9	62.9	75.3	57.4	70.5	75.4	83.0	69.8	75.3	85.7	74.5	78.0
16	Air used at atm. press. and temp. of line 11 in cub. ft. per min.	117.0	137.0	172.0	198.0	217.0	241.0	76.3	95.6	111.0	136.0	158.0	178.0	228.0	266.0
17	Do. per cubic foot of water pumped	5.3	5.42	5.81	6.59	6.67	7.19	7.13	6.42	6.29	7.09	7.16	7.62	8.94	9.94
18	Air pressure, barometric, lb. per in.² abs.	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
19	Air pressure in air receiver, lb. per in.² gauge	134.0	133.0	139.5	142.0	145.0	149.0	119.0	121.0	124.5	124.0	128.5	133.0	143.0	152.0
20	Air pressure at well head, lb. per in.² gauge	131.0	131.0	136.0	138.0	142.5	145.8	118.0	120.0	122.5	122.0	125.0	129.0	140.0	149.0
21	Air pressure equivalent to submersion, lb. per in.² gauge	129.4	125.7	126.2	124.5	123.6	123.3	114.5	114.5	114.1	113.7	113.2	112.8	111.5	110.6
22	Compressor air cylinders, i.h.p.	30.0	33.6	40.8	47.5	53.4	57.7	16.6	20.9	25.2	29.8	34.7	39.6	51.4	61.6
23	Energy contained in air on leaving air-injection footpiece, h.p.	16.9	19.6	24.6	28.1	30.7	34.1	10.5	13.1	15.2	18.6	21.6	24.3	31.0	36.1
24	Overall efficiency: $\frac{\text{Item 10}}{\text{Item 22}} \times 100$	34.7	36.6	35.2	32.3	30.2	28.9	34.6	38.2	37.7	34.5	34.4	32.0	27.2	24.0
25	Efficiency of eduction pipe: $\frac{\text{Item 10}}{\text{Item 23}} \times 100$	61.6	62.9	58.4	54.6	52.5	49.0	54.6	60.8	62.3	55.5	55.4	52.3	45.3	41.0

TABLE I—*continued.*

		SERIES C.								SERIES D							
1	Date	26/3/14	26/3/14	26/3/14	27/3/14	27/3/14	27/3/14	28/3/14	28/3/14	7/5/14	7/5/14	7/5/14	8/5/14	8/5/14	8/5/14	9/5/14	9/5/14
2	No. of test	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
3	No. of well tested	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
4	Duration of test, min.	120	120	120	120	120	120	120	120	90	90	90	90	90	90	90	90
5	Lift when pumping, ft.	255	256	260	265	266	267	268	270	295	297	302	312	314	314	315	319
6	Submersion, ft.	285	284	280	275	274	273	272	270	315	314	308	298	296	296	295	291
7	Ratio $\frac{\text{submersion}}{\text{lift}}$	1.12	1.10	1.07	1.04	1.03	1.02	1.01	1.00	—	—	—	—	—	—	—	—
8	Water raised per minute, imp. gal.	75.9	138.0	155.0	178.0	203.0	224.0	252.0	276.0	163.0	198.0	216.0	247.0	260.0	278.0	303.0	306.0
9	Water raised per minute, cub. ft.	12.2	22.0	24.8	28.5	32.4	35.8	40.3	44.1	26.0	31.6	34.5	39.5	41.6	44.4	48.5	49.0
10	Equivalent work done, h.p.	5.87	10.7	12.2	14.3	16.3	18.1	20.5	22.6	14.5	17.7	19.7	23.3	24.7	26.4	28.9	29.5
11	Temperature of water pumped, deg. F.	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
12	Air compressor, r.p.m.	19.0	30.5	35.2	40.7	45.6	50.8	60.4	75.0	36.4	42.6	47.1	54.3	61.1	69.1	77.8	86.1
13	Volume efficiency of air compressor, from cards, p.c.	96.0	95.8	95.6	95.3	95.4	95.2	94.9	94.5	95.8	95.6	95.4	95.2	95.2	94.5	94.4	94.2
14	Volume efficiency of air compressor, true value, p.c.	68.0	75.0	75.0	78.0	78.0	78.0	79.0	79.0	70.0	73.0	74.0	75.0	77.0	78.0	78.0	77.0
15	Air in compressor suction pipe, deg. F.	59.0	66.5	64.0	52.0	59.0	64.0	57.0	63.0	66.0	74.0	88.0	70.0	75.0	83.0	66.0	73.0
16	Air used at atm. press. and temp. of line 11 in. cub. ft. per min.	73.3	125.0	149.0	183.0	202.0	223.0	272.0	334.0	143.0	172.0	186.0	226.0	257.0	296.0	338.0	366.0
17	Do per cubic foot of water pumped	6.03	5.66	5.98	6.41	6.24	6.23	6.74	7.56	5.48	5.43	5.39	5.73	6.18	6.65	6.96	7.47
18	Air pressure, barometric, lb. per in.² abs.	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
19	Air pressure in air receiver, lb. per in.² gauge	122.2	122.0	121.2	120.5	121.0	121.0	124.3	128.7	136.4	136.6	136.0	132.5	134.0	136.0	138.0	139.5
20	Air pressure at well head, lb. per in.² gauge	122.0	122.0	120.0	118.0	118.0	118.0	120.5	124.0	134.0	134.0	132.0	130.0	130.0	131.0	132.0	134.0
21	Air press. equiv. to submersion, lb. per in.² gauge	123.7	123.3	121.5	119.3	118.9	118.5	118.0	117.2	136.7	136.0	133.5	129.3	128.6	128.5	128.0	126.3
22	Compressor air cylinder, i.h.p.	16.1	25.9	29.8	35.5	40.4	44.0	53.6	68.3	33.2	39.1	42.6	48.9	55.9	64.0	73.2	82.2
23	Energy contained in air on leaving air-injection footpiece, h.p.	10.4	17.7	20.9	25.5	28.2	31.1	37.9	46.4	21.1	25.2	27.2	32.6	37.1	42.6	48.6	52.4
24	Overall efficiency $\frac{\text{Item 10}}{\text{Item 22}} \times 100$	36.5	41.2	40.9	40.3	40.4	41.2	38.4	33.1	43.7	45.3	46.2	47.6	44.1	41.3	39.5	35.9
25	Efficiency of eduction pipe $\frac{\text{Item 10}}{\text{Item 23}} \times 100$	56.5	60.3	58.4	56.0	57.9	58.2	54.1	48.8	68.9	70.4	72.4	71.4	66.5	62.1	59.5	56.4

and the head be maintained within the limits tested by Professor Durley. In this meter the discharge will be found by means of the formula :—

$$Q = 0.1632\ C\ d^2 \sqrt{\frac{i}{T} p},$$

in which—

i is the difference of pressure on the two sides of the orifice, measured in inches of water.

p is the average of the absolute pressures of the air on the two sides of the orifice.

From the foregoing formulæ, the volume of air is found by the formula :—

$$W = \frac{p}{53.17\ t},$$

in which—

W is the weight in pounds per cubic foot.

p is the absolute pressure in pounds per square foot.

t is the absolute temperature F.

A third and similar method of measuring the volume of air is possible through the research of Professor William Watson and Mr. Herbert Schofield, who determined the coefficient of orifices placed in the suction pipe of a compressor.*

Quantity of Water Raised.—The discharge pipes of the wells at Oilfields rise about 20 ft. above the ground, and discharge over the rims of small tanks, against curved hoods which deflect the water downwards. The pipes are bent to gradual curves, and the last few feet are inclined about 70 deg. to the vertical. Permanent derricks of a light California oil-well pattern are built over the wells, and were the discharge tanks erected vertically over the wells, they would have to be removed each time the eduction pipes were pulled. From these small tanks the water gravitates through 6-in. mains, laid along an overhead platform, to two 84,000-gallon corrugated, galvanised-iron tanks and one wooden tank of like capacity. The iron tanks average 32 ft. 9 in. in diameter, and 13 ft. 4 in. in depth. The circumference of each ring of these tanks was carefully measured and checked, also the depth of the corrugations and the thickness of the plates. These measurements were taken when the tanks were full to the level, at which the measurements were being taken, and from these figures a table of capacities was prepared for each $\frac{1}{4}$ in. of depth.

Prior to each test, the well was pumped for sufficient time to allow all conditions to become constant, and the water meanwhile delivered into one tank. At the commencement of the test the water was diverted into another tank and switched back into the first again at the end of the test. All outlets from this measuring tank were closed and under observation at all times during the test.

Such facilities for measuring the quantity of water are rarely available, but there are several alternatives, such as weirs or Venturi tubes, which give equally accurate results. Many tests record only the combined performance of two or more wells ; this is unfortunate both from the owner's point of view, and from that of engineers, as the information is too general ; the extra cost of individual meters for each well would undoubtedly be justified by showing some chance of improvement in the efficiency of one or more of the wells.

One writer who has contributed the results of some very instructive tests, measured the quantity of water pumped in a reservoir, the size of which unfortunately would only permit of runs of 10 minutes' duration. It is the author's opinion that no test of an air-lift pump should be of less than 1 hour's duration, and that it is better to run this length of time and measure the water with some form of calibrated meter, than to run shorter tests and measure the water in any other way.

Indicated Horse-Power of Compressor Air Cylinders.—For this purpose an external spring Tabor indicator, made by the Ashcroft Manufacturing Company, was used. This instrument had seen but little use, and was in perfect condition throughout. Great care was exercised throughout the tests to obtain true representations of what was taking place inside the cylinders. The revolutions of the compressor were recorded by an Ashcroft counter, and were controlled by a steam throttle governor, which was operated by the variation of both the speed of the engine and the pressure of the air in the receiver.

Nature of the Discharge from the Wells.—These observations were taken by two observers for three periods of 5 minutes each during each test. Where the discharge was 50 per cent. or more of the total cycle the intervals were remarkably constant. The value here given are averages of times observed with an ordinary watch :—

Series A.—These observations were recorded in the paper presented to the Institution of Civil Engineers, and are therefore not repeated.

Series B.—

Test 1. Periods of discharge of 35 seconds' duration at intervals of 1 minute and 12 seconds.

Test 2. Periods of discharge of 43 seconds' duration, followed by a pause of 5 seconds, then a discharge of perhaps 10 gallons, followed by a pause of 33 seconds before the cycle recommenced.

Test 3. A steady flow of emulsion ending in two short and violent ejections, the whole lasting 33 seconds. After a pause of 5 seconds, there would be a discharge of 10 gallons to 20 gallons, followed by a pause of 28 seconds before the cycle recommenced.

* Proceedings, I.Mech.E., 1912, page 517.

TABLE II.—Average Velocity of Rising Mixture in Feet per Second.

No. of test	1.	2.	3.	4.	5.	6.	7.	8.
Series A.								
At foot-piece	6.5	7.5	9.0	9.7	10.5	11.2	—	—
,, top of 4 in.	19.5	23.0	28.4	31.8	34.8	38.2	—	—
,, bottom of 4½ in.	15.9	18.7	23.0	25.9	28.3	31.0	—	—
,, top of 4½ in.	19.1	22.5	27.8	31.4	34.4	37.7	—	—
,, bottom of 5$\frac{7}{8}$ in.	15.0	17.7	21.9	24.7	27.0	29.7	—	—
,, top of 5$\frac{7}{8}$ in.	17.0	20.0	24.7	27.9	30.5	33.6	—	—
Average throughout	14.1	16.5	20.3	22.6	24.8	27.1	—	—
Series B.								
At foot-piece	3.7	4.9	5.8	6.6	7.6	8.3	9.9	11.0
,, top of 4 in.	12.1	15.5	18.1	21.6	25.1	28.1	35.1	40.4
,, bottom of 4½ in.	9.9	12.6	14.7	17.6	20.4	22.9	28.5	32.9
,, top of 4½ in.	12.0	15.2	17.8	21.4	24.8	27.8	34.8	40.2
,, bottom of 5$\frac{7}{8}$ in.	9.4	12.0	14.0	16.8	19.5	21.8	27.4	31.6
,, top of 5$\frac{7}{8}$ in.	10.6	13.5	15.8	19.0	22.0	24.7	31.0	35.9
Average throughout	8.7	11.1	13.0	15.4	17.9	20.0	24.8	28.3
Series C.								
At foot piece	3.8	6.7	7.3	9.2	10.4	11.5	13.4	15.4
,, top of 4 in.	5.2	9.2	10.7	12.8	14.3	15.9	18.7	22.0
,, bottom of 4½ in.	4.2	7.5	8.7	10.4	11.6	12.9	15.2	17.9
,, top of 4½ in.	6.2	10.7	12.6	15.1	16.9	18.7	22.3	26.5
,, bottom of 5$\frac{7}{8}$ in.	4.9	8.4	9.9	11.9	13.3	14.7	17.5	20.9
,, top of 5$\frac{7}{8}$ in.	6.2	10.9	12.8	15.4	17.2	19.0	22.8	27.3
,, bottom of 6 in.	4.3	7.5	8.9	10.7	11.9	13.2	15.8	18.9
,, top of 6 in.	5.7	9.8	11.6	14.0	15.6	17.3	20.8	25.1
,, bottom of 6½ in.	5.3	9.2	10.8	13.1	14.6	16.1	19.4	23.4
,, top of 6½ in.	6.8	11.6	13.8	16.7	18.6	20.5	24.8	30.0
Average throughout	5.3	9.3	10.8	13.1	14.6	16.2	19.3	23.1
Series D.								
At foot-piece	7.6	9.2	10.1	11.9	12.9	14.2	15.8	16.5
,, top of 4 in.	11.5	13.9	15.2	18.1	20.0	22.3	25.0	26.6
,, bottom of 5$\frac{7}{8}$ in.	7.4	8.9	9.7	11.6	12.8	14.3	16.0	17 0
,, top of 5$\frac{7}{8}$ in.	11.7	14.1	15.3	18.4	20.5	23.1	26.1	28.0
,, bottom of 6$\frac{7}{8}$ in.	7.6	9.1	9.9	11.9	13.3	15.0	16.9	18.1
,, top of 6$\frac{7}{8}$ in.	13.4	16.1	17.5	21.1	23.7	27.0	30.7	33.0
Average throughout	10.1	12.1	13.2	15.8	17.6	19.8	22.4	24.0

TABLE III.—Energy Balances of Tests in Series D.

No. of test	1.		2.		3.		4.		5.		6.		7.		8.	
Energy balance	H.P.	Per cent.	H.P.	Per cent.	H.P.	Per cent.	H.P.	Per cent.	H.P.	Per cent.	H.P.	Per cent.	H.P.	Per cent.	H.P.	Per cent.
Lost in compression and after-cooling of air	12.19	36.7	13.84	35.4	15.19	35.7	15.93	32.60	18.20	32.6	20.48	32.0	23.20	31.7	27.80	33.8
Lost in transmission from receiver to well head	—	—	0.10	0.2	0.31	0.7	0.24	0.5	0.48	0.9	0.65	1.0	0.80	1.1	0.82	1.0
Lost in transmission from well head and through foot-piece	—	—	0.10	0.2	+0.10	+0.2	0.10	0.3	0.16	0.3	0.30	0.5	0.65	0.9	1.20	1.4
Lost in kinetic energy of discharge	0.14	0.4	0.24	0.6	0.30	0.7	0.52	1.0	0.69	1.3	0.99	1.5	1.34	1.8	1.60	2.0
Energy equivalent to water raised	14.50	43.7	17.72	45.3	19.70	46.2	23.30	47.6	24.65	44.1	26.40	41.3	28.90	39.5	29.50	35.9
Energy lost in friction	0.81	2.4	1.50	3.8	1.90	4.5	2.95	6.0	3.66	6.5	4.68	7.3	6.33	8.6	6.90	8.4
Energy lost in slip & entry	5.60	16.8	5.74	14.7	5.30	12.4	5.87	12.0	8.05	14.3	10.48	16.4	11.98	16.4	14.40	17.5

Test 4. Periods of discharge of 33 seconds' duration at intervals of 23 seconds. During the interval there would be one fairly strong spurt lasting 1 second.

Test 5. Periods of discharge of 1 second at half-second intervals.

Tests 6, 7 *and* 8. Discharge similar to that of Test 5, but at higher velocities.

In all cases the discharge consisted of an emulsion of air and water, and not of alternate volumes of air and water, as Dr. Pohle claimed for his system.

Series C.—

Test 1. Periods of discharge of 42 seconds' duration at intervals of 2 minutes and 7 seconds.

Test 2. Periods of discharge of 36 seconds' duration at intervals of 50 seconds.

Test 3. Periods of discharge of 41 seconds' duration at intervals of 26 seconds.

Test 4. Periods of discharge of 2 seconds to 4 seconds' duration at intervals of 2 seconds to 5 seconds. Very irregular.

Test 5. Very similar to that of Test 4.

Test 6. Similar to Tests 4 and 5, but the intervals did not exceed half a second.

Tests 7 *and* 8. Very similar to Test 6.

Series D.—

Test 1. Periods of discharge of 40 seconds' duration at intervals of 52 seconds. During these intervals, however, there were five discharges of 1 gallon to 10 gallons each.

Test 2. Periods of discharge of 5 seconds' duration at intervals of 5 seconds.

Test 3. Periods of discharge from 5 seconds' to 10 seconds' duration at intervals of 5 seconds.

Test 4. Periods of discharge of short duration, one beginning before the previous one had quite subsided. The velocity of discharge did not appear to be as high as in Tests 2 and 3.

Test 5. Similar in nature to that during Test 4, but at higher velocity.

Tests 6, 7 *and* 8. Practically continuous discharge of emulsion of small air bubbles and water.

Method of Recording Observations.—The comparison and analysis of published tests will be greatly simplified, if some standard form can be adopted. Most of the published tests lack certain important items, and other information, such as the submersion, is given in different ways, so that their analysis requires considerable work.

The author has adopted what he believes to be the most convenient form, and one which includes all details necessary to examine the behaviour of the pump itself. The observations might, of course, be extended to include every part of the plant down to the fuel consumption but such details can be foretold with fair accuracy by the manufacturers of the compressor. Since efficiencies of 80 per cent. seem possible with the air-lift pump in the near future, as shown later, it would not seem inopportune for some authoritative body to outline a method of making and recording tests of the air-lift pump, and its reverse, the entanglement type of hydraulic air compressor.

Probable Accuracy of the Tests at Oilfields.

Lift.—This was measured within 1 ft., equivalent to 0.4 per cent., and did not vary more than 1.5 ft. during any one test.

Quantity of Water Pumped.—The depth in the measuring tank was recorded by three independent readings to the nearest ¼ in., which is equivalent to :—

8.7 cub. ft. in 2,652 or 0.33 per cent. in Test 1 of Series A.
8.7 cub. ft. in 1,284 or 0.68 per cent. in Test 1 of Series B.
8.7 cub. ft. in 1,458 or 0.60 per cent. in Test 1 of Series C.
8.7 cub. ft. in 2,340 or 0.37 per cent. in Test 1 of Series D.

Revolutions of the Air Compressor.—The probable maximum error would be 5 in 7,750 in Test 8 of Series D.

Volumetric Efficiency of Compressor.—The probable error in measuring the volume of air flowing through the orifice during the tests of Series D is not more than 2 per cent., as the pressures and temperatures were all recorded within this margin. The values assumed for the tests of Series A, B and C, were based on the experiments made in April and May, 1914, taking into consideration the following :—

1. The speeds of the compressor.
2. The known condition of the air valves and guides.
3. The volumetric efficiency shown on the indicator cards.
4. The temperature of the air in the compressor suction pipe.
5. The known condition of the scale in the cooling jackets, and the quantity of cooling water supplied. The cooling water was supplied by a piston pump driven direct from the compressor crankshaft, in all cases.

It is difficult, therefore, to form a definite opinion of the probable accuracy of these latter values.

Indicated Horse-Power.—The maximum difference between the highest and the lowest "mean effective pressure" recorded during any one test, for the same end of a cylinder was 1.3 per cent. for the low-pressure cylinder, and 1.8 per cent. for the high-pressure. Considering the attention paid to details in the use of the indicator and the low speed of the compressor, the probable accuracy of the values given for the indicated horse-power is within 1 per cent.

(To be continued.)

TABLE IV.—*Details of Eduction Pipes used in Series A, B, C and D of Tests.*

Series A and B.—Air-injection foot-piece. In Series A as shown in Fig. 1 (page 561), and in Series B as shown in Fig. 1a.

Eduction pipe, commencing from the bottom :—

	Ft.
4$\frac{7}{8}$-in. diameter pipe	356
4$\frac{7}{8}$-in. ,, ,,	109
5-in. ,, ,,	82

The change from one size of pipe to another was made by nipples 1 ft. long bored to a uniform taper.

Air pipe was standard 1¼-in. lap-weld pipe. This eduction pipe was in constant use after being installed in December 1911.

Series C.—Air-injection foot-piece as shown in Fig. 2, the :—

	Ft.
4$\frac{7}{8}$-in. internal diameter pipe	62
4$\frac{7}{8}$-in. ,, ,,	101
5-in. ,, ,,	95
6-in. ,, ,,	131
6½-in. ,, ,,	151

The air pipe was standard 1¼-in. lap-weld pipe. At the time of the tests, the eduction and air pipes had been in constant use since June 18, 1913, and were badly encrusted internally.

Series D.—Air-injection foot-piece as shown in Fig. 3. Eduction pipe, commencing from the bottom :—

	Ft.
4$\frac{7}{8}$-in. internal diameter pipe	97
5-in. ,, ,,	166
6½-in. ,, ,,	347

The change from one size to another was made through nipples 18 in. long bored a uniform taper.

Air pipe. The lower 249 ft. was 2 in. standard pipe, and upper lengths 1¼ in.

At the time of the tests the eduction-pipe had been in use since May 1, 1914.

The Japanese Shipbuilding Industry.—We read in *The Marine Journal*, New York, that the modern shipbuilding industry in Japan dates from 1854, when a Russian vessel was wrecked on the Japanese coast. In 1860, the Nagasaki Dock was completed, and in 1866 the first steamship built in Japan was launched. By 1879, there were 13,000 tons of shipping under the Japanese flag, comprising seven vessels. Fifteen years later, in 1894, the number of Japanese ships was 400, with an aggregate tonnage of 167,000 tons. The most recent statistics show that there are 68 Japanese shipowners who own tonnage of over 2,500 tons, and their 589 vessels aggregate 1,634,000 tons in round numbers.

The Royal Institution Christmas Lectures.—Professor J. A. Fleming, D.Sc., F.R.S., will deliver a Christmas course of six illustrated lectures (adapted to a juvenile auditory) on "Our Useful Servants: Magnetism and Electricity." "Magnets and the Magnetic Compass," Thursday, December 27, 1917, at 3 o'clock; "Electricity and Electric Currents," Saturday, December 29; "The Electric Current as a Heater and Chemist," Tuesday, January 1, 1918; "Electricity as an Illuminator and Doctor," Thursday, January 3; "Electric Dynamos, Motors, Transformers and Railways," Saturday, Jauuary 5; "Electric Telegraphs and Telephones," Tuesday, January 8. Subscriptions (for non-members) to this course, one guinea (juveniles under 16, half-a-guinea); to all the courses in the session, two guineas. Tickets may now be obtained at the office of the Institution.

Electric Arc Welding.—The welded fastening, reports *The Railway Mechanical Engineer*, has always been looked upon as a stronger joint than the riveted or bolted fastening. As a general proposition, the riveted joint or bolted joint has a tensile strength which is considerably less than the tensile strength of the original piece, while the welded joint is as strong as the original section. There are two kinds of electric arc welding, known as carbon electrode welding and metal electrode welding. In the former, an arc is drawn between a carbon electrode, the piece to be welded and the metal to be added, fed into the arc in the form of a "melt-box." This method is not used extensively in railway work, due to the fact that welding may only be done in the horizontal plane in this manner, and that the work is in general inferior to that which is possible with the metal electrode process. The metal electrode process uses, as the name implies, a metal electrode, the arc being drawn between the electrode and the piece being welded. The heat of the arc melts the metal of the piece and the metal of the electrode simultaneously. As the metal of the electrode melts it is drawn across the arc and a complete and homogeneous union is formed with the molten metal of the piece. With the exception of work with certain electrodes (manganese steel and slag covered electrodes), the electrode is always made the cathode or negative, i.e., the current flows from the piece being welded to the metal electrode. The voltage required for metal electrode welding is about 20 volts, and direct current is necessary.

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The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

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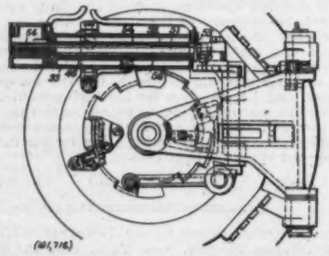
GUNS AND EXPLOSIVES.

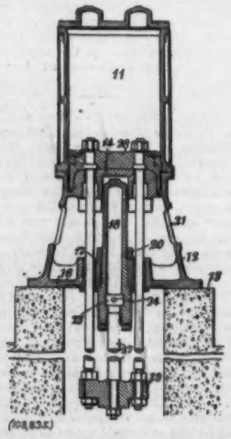
101,716. D. F. Asbury, Washington, D.C., U.S.A. Breech Mechanism. (4 *Figs.*) October 4, 1915.—This invention relates to power-operated breech mechanism of the kind having a brake device comprising a reciprocatory element which moves constantly with the breech-actuating motor to control the movements of the breech mechanism. According to the present invention, the breech-actuating motor comprises a reciprocatory element which is rigidly connected to and moves with the reciprocatory element of the brake device during its entire stroke. The said motor is constituted by a piston 46 and a cylinder 33, and the brake device may also comprise a piston 51 and a cylinder 34 arranged within the motor cylinder 33, the brake piston being connected to the motor piston so that they move together during the whole of the stroke of the motor piston in both directions. The piston rod of the brake passes through a gland or packing 53 at one end of the brake cylinder 34, and means are provided for preventing this packing from being



subjected to the braking pressure of the fluid in the brake cylinder. For this purpose, the brake cylinder may be provided with an internal flange 56, and the brake piston and piston rod may be formed with a by-pass 54, which is adapted to establish communication between the portions of the cylinder at each side of the said flange at a certain period during the movement of the piston towards the packing, so that the portion of the cylinder between the flange and the packing is placed in communication with the low-pressure side of the piston. The motor cylinder may have connected thereto a liquid-brake reservoir, which may be provided with a trap device in communication with the interior of the reservoir and with the atmosphere, this trap device not only ensuring that the liquid in the reservoir will always be at atmospheric pressure, but also preventing leakage therethrough of the liquid during the recoil and run-out movements of the gun. (*Sealed.*)

HYDRAULIC MACHINERY.

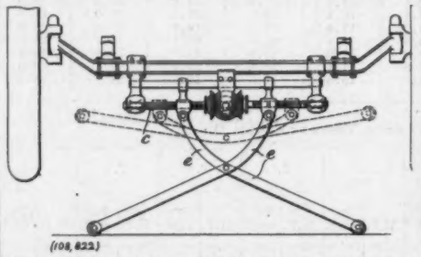
108,835. Davy Brothers, Limited, and T. W. Hand, Sheffield, Yorkshire. Steam Hydraulic Intensifiers. (4 *Figs.*) May 10, 1917.—This invention relates to steam hydraulic intensifiers such as are used, for example, in connection with hydraulic forging presses, shears and the like, and wherein the steam cylinder is mounted above, and in vertical axial alignment with, the hydraulic cylinder and ram. The steam cylinder 11 of the intensifier is mounted upon a stool 12, which rests upon the foundation 13, the bottom cover 14 of the steam cylinder



being integral with the stool, which latter is a single casting having formed in one with it the passage for the supply and exhaust of steam to and from the cylinder 11. The stationary member of the hydraulic portion of the intensifier is the hydraulic cylinder, and the bottom member 16 of the stool 12 is provided with a central bearing 17 through which the hydraulic cylinder 18 is passed from beneath, and against the lower end of which bearing abuts an external shoulder formed on the cylinder 18 towards its open lower end; whilst a nut 20 screwing on a threaded portion of the cylinder 18 engages the upper end of the bearing 17 so as to sustain the weight of the cylinder. The cylinder 18 extends upwards, above the nut 20, to near the bottom cover 14 of the steam cylinder, but without coming in contact with the latter, or with any part of the stool; and as the side walls of the stool 12 are apertured, as at 21, to permit free circulation of air through the space within the stool, very little heat is able to reach the cylinder 18 by conduction through the stool from the steam cylinder 11. Beneath the level of the external shoulder, the bore of the hydraulic cylinder has an enlargement 23, from which extends laterally a passage 24 leading to the hydraulic main-pressure pipe. Below the enlargement 23, the cylinder 18 is provided with a hydraulic stuffing-box giving passage to the ram 27. The steam piston 28 (which is shown as occupying its lowest position) is coupled to a crosshead 29 on the lower end of the hydraulic ram 27, by means of a pair of side rods, which pass through stuffing-boxes in the bottom cover 14 of the steam cylinder 11, and extend on opposite sides of, and parallel to, the common vertical axis of the cylinders 11 and 18, these stuffing-boxes being preferably provided with steam packing of the floating metallic type (not shown) adapted to yield to lateral strains due to any slight deviation from parallelism between the respective rods. The rods are also guided by passing through renewable bushes held in sockets provided in the base 16 of the stool 12 alongside of the bearing 17, so that any shake which may tend to arise in these relatively long and slender rods (particularly when put suddenly under longitudinal stress) may be prevented as far as possible from affecting the various packings. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

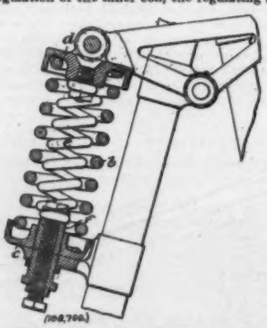
108,822. F. L. Rapson, Liverpool, Lancashire. Lifting Jacks. (6 *Figs.*) March 22, 1917.—This invention relates to lifting jacks for use on motor road vehicles. The invention consists in providing adjacent to the front and rear axles, or other convenient parts of the chassis, one or more pairs of pivoted or scissors-like levers *c*, the upper ends of which are adapted to be moved closer together or further apart by rotatably mounted



right and left-handed screw-threaded rods *e* driven from the engine or by other suitable means, such as a hand wheel, so that the lower ends of the said levers will engage the ground and raise the vehicle when the upper end of the levers are moved in one direction, or the lower ends of the levers will be drawn up and out of action when their upper ends are moved in the opposite direction. (*Sealed.*)

MOTOR ROAD VEHICLES.

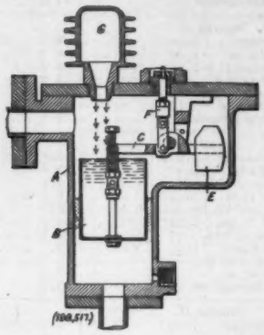
108,700. N. T. Downs, Moseley, Birmingham, and A. H. Tonks, Sparkhill, Birmingham. Shock-Absorbing Springs. (3 *Figs.*) August 11, 1916.—The invention has reference to shock-absorbing springs of the type wherein a coiled shock-absorbing compression member is associated with a coiled extension member that functions as a check or rebound spring and is located within the axis of the compression member, one of its extremities being fixed to the corresponding abutment of the compression members, whilst the other extremity is anchored to the other abutment by an adjusting screw. According to this invention, the inner coil has a bearing against, and is adjusted by, a screwed or wormed sleeve carried by one of the abutments of the outer coil, the said inner coil being clamped or anchored to the sleeve by a second screw, and after the adjustment or regulation of the inner coil, the regulating sleeve can be



secured or locked in its adjusted position. The outer coiled member *b* of the compound spring is interposed, in compression, between a lower fixed abutment *c* on the main part of the motor-cycle frame and another and relatively movable abutment *d* that is connected, by a system of levers, with the parts of the frame wherein the rear road-wheel is mounted, whilst the other extensible spring member *a* is located axially within the compression member, and whilst its upper end may be directly anchored to the abutment *d*, its lower connection is made through the medium of a screwed adjusting sleeve *f*, so that it is capable of being raised or lowered at will for varying the normal distance between the top of the said sleeve and the movable abutment, and consequently regulating the normal compression on the inner spring. A lock nut is provided, on the lower end of the adjusting sleeve *f*, for locking the latter in its adjusted relationship to the fixed abutment. (*Accepted August* 29, 1917.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

108,517. A. H. Anthony, Colchester, Essex. Float-Controlled Feed Regulators. (2 *Figs.*) August 7, 1916.—This invention relates to boiler-feed float apparatus of the kind in which a float, buoyed up by water and exposed to the steam at boiler pressure in a vessel, is arranged to operate or control some device automatically by variation of the level of the liquid in the vessel, which said device determines the feed to the boiler. According to the present invention, in float apparatus of the kind defined, an open and partly balanced unsubmerged float is combined with means to condense some steam from the boiler and automatically deliver it as water continuously or with regularity into the open and unsubmerged mouth of the float. A vessel A is provided to constitute the float chamber and contains a float B suspended upon a lever C. The float consists of an open bucket. At the other end of the lever is a balance-weight E and an arm F connects the lever to a valve which serves to control the feed to the boiler, the connections being such that when the float end of the lever is depressed feed water is admitted to the boiler, and when that end rises the feed is cut off. The bucket B is suspended from the lever C, so that its mouth



automatically remains horizontal. Above the bucket is a condenser G secured in the roof of the chamber A, the condenser being in the form of a domed vessel, whose mouth is downwardly directed and is so placed that the condensed steam drips from the condenser into the bucket. The bucket, the proportions of the pivoted lever, and the counterbalance, are so chosen that the bucket, when full of water, is balanced by its counter-weight when it is about half immersed. It is normally kept full by the drip of condensed steam from the condenser, but in a heavy sea-way the bucket will spill some of its liquid content, and will therefore be balanced by the counter-weight when it is less immersed than normally, and will thus keep the level of water in the boiler slightly lower than ordinarily. The counter-weight is preferably not immersed. (*Sealed.*)

108,690. The Hon. Sir C. A. Parsons and S. S. Cook, Wallsend-on-Tyne, Northumberland. Steam Superheaters. (9 *Figs.*) May 13, 1916.—The invention relates to steam superheaters. The object of the invention is to prevent excessive heating of the superheater tubes, when the ordinary consumption of steam is reduced or ceases, by regulating or closing down the regulating valves in the steam supply pipes. The invention consists in means for preventing overheating in superheaters, comprising an additional relief valve at the exit end of the steam space of the superheater, such additional relief valve being arranged to blow-off at a lower pressure than the relief valves on the boilers which supply steam to the superheater. The boiler *a* is of the ordinary Scotch type, and the superheater *b*

Fig. 1.

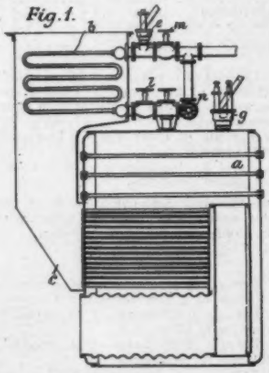
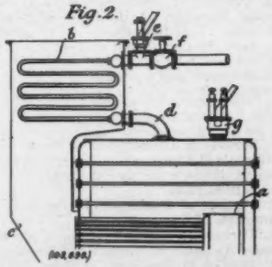


Fig. 2.



is fitted in the uptake *c*. The steam leaves the boiler *a* and passes through the pipe *d* to the superheater *b*, whence it passes through the safety valve *e* and stop valve *f* to the engines. The superheater safety valve *e* is provided in addition to the ordinary boiler safety valve *g*. In such an installation the valve *e* would preferably be set to blow-off at a slightly lower pressure than the valve *g*. By retaining the ordinary boiler safety valve *g* it is permissible to fit the valves *l*, *m*, *n*, as shown in Fig. 1, by means of which the superheater can be shut off and the steam passed direct from the boilers to the engines. In such case any known baffling devices may be provided, adapted to be brought into position to protect the superheater tubes when these are not in action. (*Sealed.*)